ARCHIVES of OPHTHALMOLOGY

VOLUME 4 (old series Volume 61) JULY, 1930 NUMBER 1

SOME PRACTICAL PROCEDURES USED BY DR. HAROLD GIFFORD*

S. R. GIFFORD, M.D.

CHICAGO

It was not with the idea of giving a complete historical review of my father's work that I chose this subject, as this is accessible in the literature, and the most important part of it is already known to most ophthalmologists. What I thought would be more interesting than anything of my own is a description of procedures, some of which may seem trifling, but which, taken together, made up a routine of painstaking care which, I believe, in difficult cases often made the difference between success and failure.

I will mention only his more important scientific work because some of it seems in danger of being forgotten, and he was never one to spend much time in insistence on priority for his own ideas. The substance of the theory that organisms live on the conjunctival epithelium, and hence the idea of the value of epithelial scrapings in examining the conjunctiva, which Lindner and Howard so well worked out, was stated explicitly in an article of my father's published in the ARCHIVES OF OPHTHALMOLOGY in 1898. He mentioned that many more colonies are to be obtained by scrapings of the conjunctiva, made exactly as Lindner has recommended, than by the ordinary methods. This idea was followed up in another paper written in 1903. Here he also brought out the importance of the normal conjunctival flora which is always present.

An earlier piece of bacteriologic work which seems to me important was published in 1896. It was the first report in English on the pneumococcus as a cause of acute conjunctivitis. It contained the description of forty cases, in all but six of which the pneumococcus was found. The conclusion was drawn that it was the principal cause of acute conjunctivitis in Omaha, where the work was done. In this article were also reported the first successful attempts to reproduce the disease on the human conjunctiva, my father's own conjunctiva and that of an assistant being used for the purpose, and also the first successful production of the disease from pure cultures on two other normal conjunctivae.

* Submitted for publication, April 3, 1930.

* From the Department of Ophthalmology, Northwestern Medical School.

* Read before the Eye Section, New York Academy of Medicine, Feb. 17, 1930.

In 1898, he made the first report in English on the Morax-Axenfeld bacillus, having found it not only in conjunctivitis, but also in a severe corneal ulcer. In a later article in which he described the allied organisms discovered by Petit and Rochat, he called attention to the practical point that the frequent mild cases of conjunctivitis due to this organism show scarcely any signs of ordinary conjunctivitis—merely a slight redness of the lids and symptoms of irritation. These can be diagnosed only by a smear made from the inner angle, which usually shows countless organisms. He also described two little known forms of the disease: an acute form with much swelling of the retrotarsal folds and a chronic form with granulations, which may greatly resemble those of trachoma.

Having settled in a part of the country where there were few trained ophthalmic surgeons, he had only commenced his scientific work when he found himself in the midst of a practice that kept him from devoting much time to pure laboratory work. Hence his later work was chiefly the result of clinical observation. The habit of wide reading of the foreign ophthalmologic literature made him quick to recognize unusual and interesting conditions, so that he was able, in 1898, to give the first description in English of Parinaud's conjunctivitis and to report five cases. In the same way, his case of sporotrichosis of the bulbar conjunctiva, reported in 1910, was the first record in English of an ocular involvement with *Sporothrix*. In this instance, his bacteriologic experience enabled him to prove his diagnosis by culture. He also reported several cases of palpebral sporotrichosis at this time.

The signs of exophthalmic goiter that have been known by my father's name should hardly need description here, since I find that they were first described before the New York Academy of Medicine in 1906. The one that is best known, difficulty in everting the upper lid, was also observed by Dr. C. S. Bull, as he mentioned in discussing my father's paper. What is worth remembering is that this difficulty of eversion, which is so marked as to bend the tarsus in the middle and to blanch its vessels completely, is not simply a mechanical difficulty due to the exophthalmos. It occurs very early, often disappearing as the exophthalmos develops, and hence it is of real value in the diagnosis of hyperthyroidism. It was interpreted as due to a spasm of the smooth muscle levator through its sympathetic innervation. In my experience it is to be found in about 50 per cent of cases. The other sign, a solid edema of the upper lid just beneath the eyebrow, especially near the outer angle, is also an early sign, and I can testify to its occurrence in many cases in which the exophthalmos was minimal.

What is sometimes known as Gifford's lid reflex is the contraction of the pupil on closure of the lids. My father described this in 1895, mentioning its persistence in certain cases of tumor of the brain and oculomotor paralysis in which the reactions to light and convergence

were absent; he called it the orbicularis reaction. Later he found that it had previously been described by Galassi in 1889. In 1900 he called attention to this fact and suggested that the name "palpebral reaction," proposed by Galassi, should properly be used.

A large number of my father's practical procedures, or their equivalent, must have been arrived at by any ophthalmologist of his judgment, knowledge and experience. The knowledge was founded on an excellent training at the hands of such masters as Horner of Zurich and Herman Knapp of New York, and was constantly being enlarged by persistent reading.

What I considered his unusual therapeutic resourcefulness was based on minute and constant self-criticism. He made it a rule, which he admitted was not always kept, to spend a little time every night in thinking over difficult cases, considering what changes in treatment might be made in those which were not progressing well. Whether or not this was the cause, I have never known any one so quick to realize when things were not going well, nor so quick to provide the necessary changes in management. Always anxious to try new procedures that he read of, he was seldom unduly enthusiastic, and decided without much waste of time which of the measures should be added to his therapeutic routine.

OPERATION FOR DECREASE IN TENSION

After obtaining from Curran's basal iridotomy a decrease in tension in a number of cases of chronic glaucoma, he reported favorably on this procedure. When, after two years, he found that the tension rose again above normal in a number of cases, he reported this change of opinion at once. The method was then reserved for a small number of cases of secondary glaucoma with a shallow anterior chamber in which a double iris puncture according to the method of Fuchs was not successful. It was done with a very sharp Knapp needle, which was introduced subconjunctivally at the limbus, passed through a peripheral segment of iris and then brought straight out through the limbus subconjunctivally. This change from the Curran technic was made because it was so difficult to cut the bridge of iris without also cutting the sclera, and because the sclerectomy seemed in itself to offer possible advantages. In one case of acute glaucoma with shallow chamber, in which an operation was performed on the day of the attack, I saw a permanent normalization of tension obtained in this way, with normal vision. I say permanent because the tension was found to be normal only a few months before the patient's death about four years later. In some cases of acute glaucoma, when the patient is seen on the first day of the attack, a paracentesis alone, if preceded and followed by the injection of physostigmine, will abort the attack; the pupil will remain contracted with physostigmine and the tension will return to normal. I

have seen my father succeed in several cases by this means alone. I remember a patient of my own, an old lady who was expected to die of pneumonia, whose physician refused to consider any operation and who retained good vision for several years following a paracentesis done at her home under cocaine anesthesia. She used physostigmine, and had no further attacks till her death.

My father always performed paracentesis and discissions subconjunctivally, as he believed that this allowed less chance of both infection and prolapse of the iris. This procedure is facilitated and made painless by the injection of a drop of 2 per cent cocaine under the conjunctiva so as to form a bleb near the limbus where the puncture is to be made, and also by the use of a very sharp cataract knife ground down so as to be not over 3 mm. wide.

Paracentesis or any intra-ocular operation is always facilitated by good fixation of the globe. Long before the "Zugelnaht," or suture

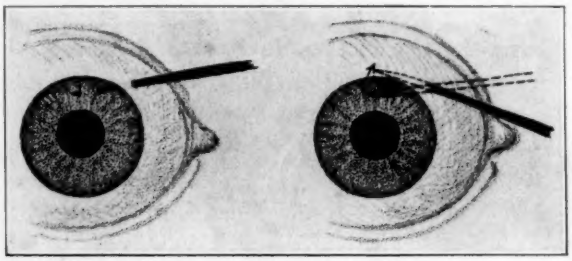


Fig. 1.—Peripheral iridotomy.

through the superior rectus, came into such general use as at present, my father accomplished the same result by means of his fixation forceps with a clamp and long teeth, by which the tendon could be grasped through the conjunctiva. Its use required the injection of a drop of cocaine over the muscle insertion, after which it was quite simple to grasp the muscle with the forceps and much less trouble than to place a suture. In the operation for cataract, fixation was usually made on the internal rectus, but when the patient had any difficulty in looking down, the superior rectus was fixed and sometimes also the internal rectus. This fixation is of especial value when one does a trephining or iridencleisis. I am sure that without it, my father could never have made the large conjunctival flaps or careful sutures which he insisted on in these operations. The clamps on these forceps were slide clamps and were always kept well lubricated with petrolatum, so that they could be released in an instant. The sunken eyes sometimes seen in patients with cataract of long duration could actually be pulled forward by this fixation on the two recti, so that it was seldom necessary to do a

canthotomy, and the worries over patients who cannot look down were practically obviated. The forceps devised by Elschnig are, so far as I can see, identical with my father's.

Fixation with a thread was another of his practical tricks which was often useful. In pterygia, small epibulbar tumors or dermoid cysts of

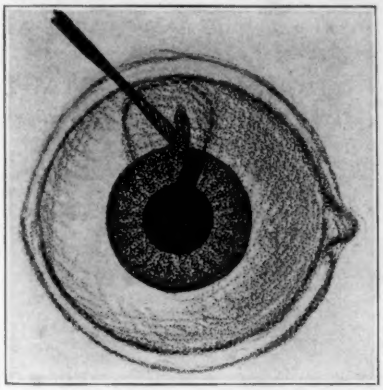


Fig. 2.—Subconjunctival prolapse puncture.

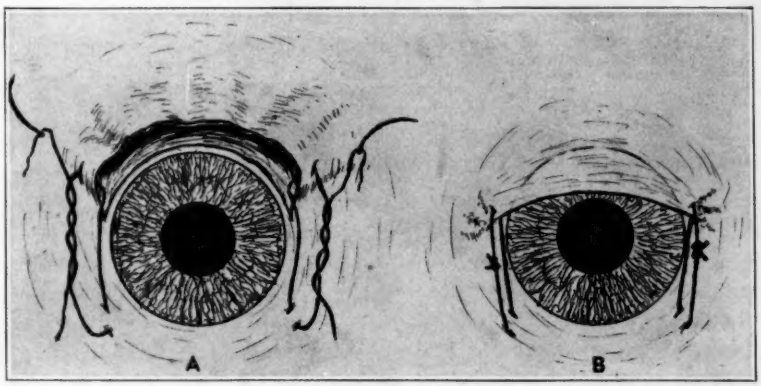


Fig. 3.—Sliding conjunctival flap for cataract operation: *A*, first stage, and *B*, second stage.

the lids, he would often transfix the growth with a suture on which gentle traction was made while the dissection was done. Such little growths as were suspected of malignancy were usually outlined with a fine electrocautery point before being removed, so as to avoid inoculation of healthy tissue with the knife. Their base was thoroughly cauterized after removal.

Like any good ophthalmic surgeon, my father realized the necessity of avoiding all pain in intra-ocular operations. A few trials of retrobulbar anesthesia taught him the marked and sometimes alarming hypotension which this often produced, but he never operated for cataract without the injection of two or three drops of 4 per cent cocaine subjunctivally, after which he would wait four minutes before operating. This was preceded by one drop of 2 per cent and three drops of 10 per cent cocaine instilled in the sac at two minute intervals. With such preparation the patient seldom felt the slightest pain, so that the tendency to squeeze when the iris is cut was seldom seen. Hence he used akinesia in relatively few cases. I never saw any harmful effect from the 10 per cent cocaine, as the lids were kept closed between drops, and a few drops of boric acid were used on the cornea during the operation. In acute or inflammatory glaucoma, in which local anesthesia is difficult and uncertain, he always operated under general anesthesia.

OPERATION FOR CATARACT

In operations for cataract my father nearly always employed iridectomy and cystotomy. The conjunctival flap was made with the knife; by injecting a little cocaine at the site of puncture and allowing a few drops of aqueous to escape subconjunctivally before the conjunctiva was counterpunctured, a large flap was usually made covering the wound at both angles. For this reason I do not remember having seen free prolapse of iris after any of his operations. The few times that prolapse did occur, the iris was covered by conjunctiva and if the prolapse was extensive, subconjunctival puncture was made later. This subconjunctival prolapse puncture is a most useful procedure, not only in these rare cases, but also after an iridencleisis, when the tension rises above normal and a conjunctival bleb is not formed. It is done by injecting cocaine to produce edema around the prolapsed part. Then a fine knife is passed through the conjunctiva and iris into the anterior chamber, turned a little and withdrawn. This has often resulted in a good bleb with normal tension in those rather exceptional cases in which not enough effect on the tension was produced by the operation.

Although he usually made the flap for a cataract operation with the knife, without the use of sutures, whenever trouble was expected—as with a dislocated lens, a very hypermature cataract, a very old patient, or one with a high degree of myopia—he always considered it necessary to take extra precautions. In these cases a sliding conjunctival flap from above, according to the method of Kuhnt, was used. The conjunctiva was dissected loose from the upper half of the limbus and undermined well back to the fold, so that it pulled down easily well over the limbus. Two sutures were placed from near each outer end

of the flap to the bulbar conjunctiva below the limbus and to each side; one turn was taken in each of these, and they were laid aside on pieces of wet gauze so as not to interfere with the operation. They were tied after it was over, but only tightly enough to pull the flap from 3 to 4 mm. over the limbus. By the time the stitches were removed, the flap had usually retracted nearly to the limbus; it never adhered to the cornea, the epithelium of which was left intact. (When it is desired to make such a flap adhere to the cornea, as after a penetrating wound, the corneal epithelium must be removed by a careful application of

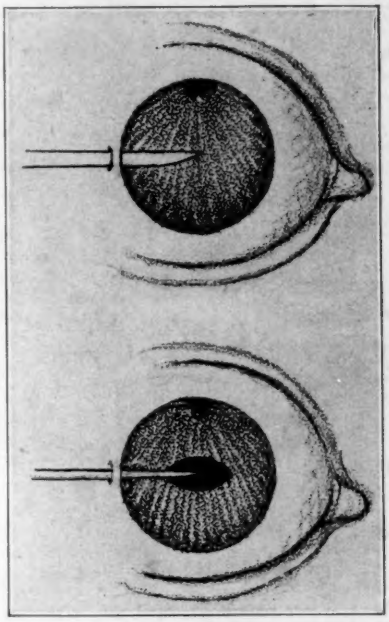


Fig. 4.—Iridotomy for displacement of the pupil.

trichloracetic acid.) This flap, which my father considered the safest for an operation for cataract, has no drawbacks except the time consumed in making it. If it is dissected freely enough, it is a great help when loss of vitreous occurs. It is a great comfort, also, with unruly patients. I have never seen a subsequent rupture of the wound such as one sees so often in European clinics. Prolapse of the iris is also very rare, and when this occurs, the prolapse is subconjunctival. I have used the procedure in practically all my operations for cataract, and believe that the time spent on it is well repaid by the additional feeling of safety afforded. It seems to me to be the method of choice to teach to assistants, as with its use the exact location of the incision is not so all-important, and there is no tendency to make the incision too deep,

as is possible when all one's attention is given to obtaining a proper flap with the knife.

When vitreous presents after the section, and a loop must be used, I know of none better than one devised by my father, with four sharp teeth on the concave surface. These engage the lens without the necessity of pressing it forward against the cornea, and more than one attempt is seldom necessary.

When one has a patient whose pupil is drawn up to the wound after an operation for cataract, the Ziegler V-shaped excision gives a good opening, but is a delicate operation and one not without danger of loss of vitreous and other complications. In these cases my father always used a procedure apparently just like that described by Dr. Wheeler a few years ago. It was not original with him, but was first used, I believe, by Theobald. It consisted in inserting a thin cataract knife at the limbus and giving a quick stab through the iris well past the center of the pupil, followed by a quick sawing pull. As the atrophic iris is already on the stretch, it retracts, and often an almost perfectly round pupil results. The knife described by Dr. Wheeler seems to be admirably adapted for this procedure.

Little need be said about my father's treatment for sympathetic ophthalmia. His formula for dosage, 1 grain (0.06 Gm.) of sodium salicylate per pound per day, or about 150 grains (9.7 Gm.) a day for the average man, is well known. I need only to emphasize his admonition that when ordinary doses are not giving results the dose may and should be increased to 180 or 200 grains (11.6 or 12.9 Gm.) a day for the average patient and more for a large patient. He always gave it as 1 ounce (31.1 Gm.) of the sodium salt in a 4 ounce (124.4 Gm.) mixture, with 1 ounce of simple elixir. When this was not tolerated by mouth, 60 grains (3.9 Gm.) by rectum was given two or three times a day. These doses were also used, of course, in any severe case of iridocyclitis. In long drawn-out cases, cincophen was sometimes substituted with equally good results, and in late years, neocinchophen has also been used and seems better tolerated than any of the three.

In trachoma, of which he saw a great deal in Omaha, my father seldom excised the tarsus. He always emphasized the fact that this procedure alone seldom removed all the trachomatous tissue and often caused entropion. He preferred careful expression of the folds and tarsus with a forceps much like Prince's, but with a pear-shaped prominence for getting into the angles and grasping the caruncle. This was followed by long and thorough treatment with the copper sulphate crystal. He found that patients seldom persisted long enough in such treatment unless some member of the family was taught to make the applications and wash off the lids afterward. One complication of trachoma which I believe he was the first to describe, in 1917, and which

Bachmann mentioned as a new observation a few years before the present writing, is of great practical importance in certain cases. This is the occlusion of the common canaliculus, or the inner end of each canaliculus, by the scar tissue in old cases. It is very frequent, and in many patients who are otherwise cured of trachoma the accumulation of bacteria and débris in these closed pockets keeps up a constant corneal irritation which may lead to severe ulcers. The patency of the canaliculi can seldom be reestablished by any means but by the simple procedure of slitting both canaliculi and the common canalicus, and keeping the cuts open for several days so as to transform the whole system into a part of the conjunctival sac, the cause of irritation is removed effectively.

My father's method of destroying the lacrimal sac is well known, but, so far as I can observe, not as widely employed in this country as it deserves to be. I think that this is because of the fear that trichloracetic acid will produce deep burns or will injure the skin. I have never seen any damage to the eye or skin from trichloracetic acid used in this way, and I believe that there is no more reason to fear such damage than to fear that a patient will bleed to death during an extirpation. A few points of technic, however, should be observed carefully. The patient should be seated during the procedure, so that the acid does not run out of the canaliculi into the conjunctival sac. The skin should be protected by thick zinc oxide ointment. The incision must go into the sac, as demonstrated by a probe passed through a canaliculus. All bleeding must be stopped, and the interior of the sac dried. Then 2 drops of pure liquefied trichloracetic acid are dropped into the sac and rubbed thoroughly into all parts of the wall by an iron applicator with a small ball of cotton wrapped closely near its end, so that the cotton and acid do not touch the skin. To make sure, this procedure should be repeated once or twice after the sac is dried. The cavity is packed with thmyol iodide, which is left to absorb. Where there is much bleeding or in the case of a large mucocele, it is well to pack the cavity with gauze after opening it, and not to apply the acid until the next day. This procedure, as my father pointed out in 1923, is useful for destroying the lining of large dermoid cysts which extend deeply into the orbit. Trichloracetic acid does not produce deep burns like phenol or nitric acid. It completely destroys epithelium with which it is brought into contact, but apparently causes no appreciable necrosis of other tissues, the lymph of which rapidly dilutes it.

The Sweet method of localizing foreign bodies in the globe is generally used in this country. When one has no roentgenologist well versed in this technic or with the necessary apparatus, my father's method of marking the position of the globe is very useful. He had used it for some years before Holth reported a similar method in 1911, but it was not reported until the following year. It consists in the

introduction of a small bit of silver wire into a conjunctival pocket above and below the limbus. This gives absolutely the position of the globe on the anteroposterior and lateral roentgenogram. The position of the foreign body may be easily computed from this, without the possibility of an error in calculation such as may occur with the Sweet method when the eye is moved. A simpler method of accomplishing this was worked out by Dr. Patton at my father's instigation: with a pair of notched forceps, small silver rings are clamped to a fold of conjunctiva. Vogt's use of hooks for his boneless roentgenogram employs the same idea.

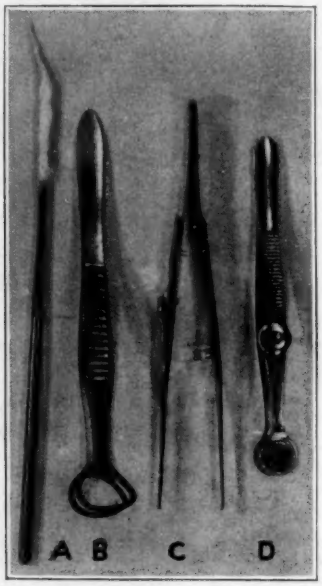


Fig. 5.—*A*, applicator for corneal ulcer; *B*, trachoma forceps; *C*, fixation forceps, and *D*, chalazion forceps.

The treatment for corneal ulcers is a large subject in itself, but I believe my father had some ideas on it that are of enough practical value to deserve mention. In the first place, his method of applying chemical agents to ulcers is a convenient and safe one. Iron applicators are ground down to a point at one end, and are etched so as to be rough for the application of cotton. A thin wisp of cotton is wrapped on the point, drawn to a fine point and cut off. If the eye moves during application, the point bends without moving over the cornea. For deep infiltrates a very small wisp of cotton is wrapped tightly over the point to make a hard applicator with which the bottom of the ulcer can be touched. Trichloracetic acid is convenient, as it turns the

tissue white so that the extent of the application can be seen. A few granules of pure ethylhydrocuprein, applied exactly in this way, will sometimes abort a small pneumococcus ulcer in one treatment. I believe that his most important procedure, however, was keratotomy, not performed late when the Guthrie-Saemisch incision is indicated, but early at a time when many would consider it unnecessary. When a small, deeply infiltrated serpent ulcer did not show signs of healing after one or two applications such as that just described, my father never hesi-

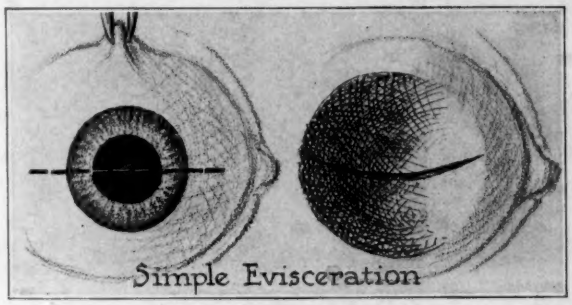


Fig. 6.—Simple evisceration.

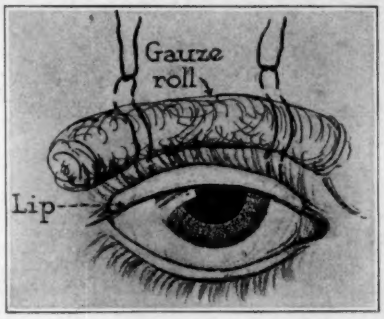


Fig. 7.—Lip-flap operation for trichiasis.

tated to perform what he called a delimiting keratotomy. By this, he meant a cut with a Graefe knife across the cornea just in front of the advancing border, extending slightly beyond the greatest diameter of the ulcer in each direction. Such a cut heals promptly, usually in twenty-four hours, and in the case of small ulcers, such a good effect may be secured that it can be allowed to heal. With most serpent ulcers, however, the cut is kept open for several days by being touched twice a day with a small pointed instrument, so that the chamber reempties. The only precaution necessary is to make certain that the chamber is not empty when the cut is reopened, in which case the procedure is unneces-

sary and might injure the lens. With severe ulcers, it may seem best to use a fine cautery point to puncture the cornea, as a round opening heals more slowly and allows the chamber to remain empty for several days. Whether the effect is due to the growth of epithelium into the cut which acts as a barrier to infection, or to the removal of tension from the cornea which allows a greater supply of lymph and antibodies is uncertain, but the effect on the healing of the ulcer is unmistakable. This statement will be borne out by any one who has tried it, or who has seen an ulcer heal after spontaneous perforation.

My father made a number of modifications of previous operations which I believe enhanced the practical value of these procedures immensely, and which I would like to describe. One of these is his method of performing evisceration with preservation of the cornea, which greatly simplifies the operation, renders stitches unnecessary and

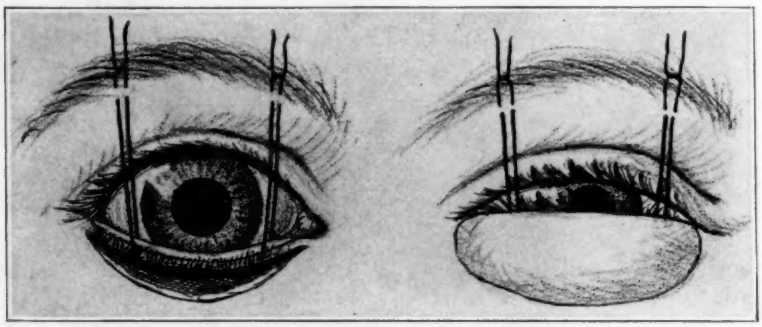


Fig. 8.—Operation for senile ectropion.

improves the resulting stump. A horizontal incision is made with a cataract knife straight across the globe through the ciliary region on both sides. The contents of the eye are removed with an evisceration spoon, and the sclera is wiped thoroughly with sponges and examined carefully to make sure no uveal tissue remains. The cornea is left in place and is simply pressed back against the sclera by means of a large sponge covered with zinc oxide ointment and placed between the lids. None of the methods of implanting bone or glass balls in Tenon's capsule really gives a better stump than is obtained by this simple method, which is applicable instead of enucleation in most cases. Other modifications are his application of the stitches over a gauze roll in the Van Millingen operation for trichiasis to hold the wound apart for a lip-flap, his mode of doing the Machek operation for ptosis and his use of Thiersch flaps and epithelial lip-flaps for the treatment of recurrent pterygium in the way familiar to ophthalmologists through Denig's description. I hope that others may use to advantage some of the

procedures which served my father well, and that I may have passed on a little of what in one of his last papers, referring to the place of old men in medicine, he called "the priceless gift of well preserved and well digested experience."

BIBLIOGRAPHY OF HAROLD GIFFORD'S WORK

A Contribution to the Study of Sympathetic Ophthalmia, Arch. Ophth. **15**:281, 1886.

Bacteriology of Phlyctenular Conjunctivitis, Arch. Ophth. **15**:180, 1886.

Further Contribution to the Study of Sympathetic Ophthalmia, Proc. 9th Internat. Med. Cong. **3**:766 (Sept.) 1887.

The Needless Prescription of Spectacles, M. Rec. **38**:10, 1890.

Embolus of a Branch of the Retinal Artery, with Nearly Complete Recovery under Massage and Nitrate of Amyl, J. A. M. A. **14**:527 (April 12) 1890.

Further Experiments on the Lymph Streams and Lymph Channels of the Eye, Arch. Ophth. **21**:171, 1892.

Minor Plastic Operations About the Eye, Arch. Ophth. **23**:18, 1894.

The Shield Dressing for Cataract Extraction, Ann. Ophth. **3**:141, 1894.

An Orbicularis Pupillary Reaction: An Unusual Case of Hyaline Bodies in the Optic Nerve, Arch. Ophth. **24**:395, 1895.

The Pneumococcus of Fraenkel as a Frequent Cause of Acute Catarrhal Conjunctivitis, Arch. Ophth. **25**:314, 1896.

On the Use of Epithelial Lip-Flaps and Half-Skin Flaps in Eye Surgery, Ophth. Rec. **6**:640, 1897.

Five Cases of Parinaud's Conjunctivitis, J. Ophth. **15**:193, 1898.

The Predominance of German Influence in Modern Medicine and Surgery, J. A. M. A. **31**:627 (Sept. 10) 1898.

The Diplo-Bacillus of Sub-Acute Catarrhal Conjunctivitis, Ann. Ophth. **7**:218, 1898.

Ten Years' Experience with the Surgical Treatment of Trachoma, J. A. M. A. **30**:128 (Jan. 15) 1898.

The Bacteriology of the Conjunctival Sac, Partly with Reference to Asepsis, Arch. Ophth. **27**:616, 1898.

Pulsating Exophthalmos from Aneurismal Varix in the Neck, Ophth. Rec. **8**:174, 1899.

Blindness from Drinking Methyl Alcohol, Ophth. Rec. **8**:411, 1899.

Thrombosis or Embolism of the Central Artery of the Retina After Ligation of the Vessels of the Neck, Ophth. Rec. **8**:595, 1898.

The Palpebral Reaction of the Pupil (Galassi), Arch. Ophth. **29**:191, 1900.

The Danger of Spontaneous Cure of Senile Cataract, Am. J. Ophth. **17**:289, 1900.

Clinical and Pathologic Notes on Sympathetic Ophthalmia, J. A. M. A. **34**:341 (Feb. 10) 1900.

On Strictly Simple Evisceration of the Eye-Ball, Arch. Ophth. **29**:422, 1900.

Hysterical Alopecia of the Eyelids, Ophth. Rec. **10**:1 (Jan.) 1901.

On the Protection of the Cornea in Some Sightless Stumps, Arch. Ophth. **31**:111, 1902.

The Essentials and Non-Essentials of Ophthalmic Asepsis, J. A. M. A. **41**:824 (Oct. 3) 1903.

On the Clinical Importance of the Diplo-Bacillus of Morax-Axenfeld, Ophth. Rec. **14**:511, 1905.

On the Disadvantages of the Dry Gauze Dressing After the Operation for Septic Thrombosis of the Lateral Sinus, Arch. Otol. **34**:304, 1905.

The Breech-Pin in Ophthalmic Surgery, Ophth. Rec. **14**:124, 1905.

A New Eye Symptom in Graves' Disease, Ophth. Rec. **15**:249, 1906.

Angioma of the Conjunctiva Successfully Treated by Injections of Absolute Alcohol, Ophth. Rec. **15**:596, 1906.

An Unusual Case of Methyl Alcohol Poisoning, Ophth. Rec. **15**:274, 1906.

Ueber Ein Neues Augensymptom bei Morbus Basedowii, Klin. Monatsbl. f. Augenh. **44**:201, 1906.

Pulsating Exophthalmos Treated by Excision of Dilated Orbital Vein, Ophthalmology **4**:20, 1907.

Some Impressions of the Basle or Inner-Pole Magnet, Ophth. Rec. **16**:55, 1907.

Retro-Bulbar Cyst of Orbit Treated by Kronlein's Operation and the Application of Carbolic Acid, West. M. Rev., 1907, p. 341.

On the Possible Use of Atoxyl and Other Preparations of Arsenic in Sympathetic Ophthalmia, Trachoma and Some Syphilitic Affections of the Eye: A Suggestion, Ophth. Rec. **17**:129, 1908.

On Sympathetic Ophthalmia After Evisceration and Mules' Operation, with a Case, Ophth. Rec. **17**:584, 1908.

The Treatment of Recurrent Pterygium, Ophth. Rec. **18**:1, 1909.

Two Cases of Vossius Ring Shaped Opacity of the Lens, Ophthalmology **5**:228. 1909.

An Instrument for Opening from the Lacrymal Sac Directly to the Nasal Cavity, Ophth. Rec. **18**:454, 1909.

Sporotrichosis of the Eyeball and Eyelids, Ophth. Rec. **19**:573, 1910.

An Aid to the Localization of Foreign Bodies in the Eye, Ophth. Rec. **21**:8, 1912.

The Juvenile Form of Family Amaurotic Idiocy, Ophth. Rec. **21**:577, 1912.

Definite Resection of the Outer Orbital Wall, Ophth. Rec. **21**:128, 1912.

Industrial and Household Accidents to the Eye, Conservation of Vision series, pamphlet 2, American Medical Association, 1913.

A Theoretical Consideration of Some Phases of Sympathetic Ophthalmia, Ophth. Rec. **23**:64, 1914.

On the Hard Plug Method of Controlling Hemorrhage Deep in the Orbit, Ophth. Rec. **23**:94, 1914.

The Therapeutics of Sympathetic Ophthalmia, Ohio State M. J. **11**:158 (March) 1915.

A Method of Destroying the Lacrymal Sac in Chronic Dacryocystitis, Ophth. Rec. **24**:22, 1915.

On the Technique of Evisceration, Arch. Ophth. **44**:162, 1915.

A Spectacle Frame for Tennis Players and Farmers, Ophth. Rec. **24**:81, 1915.

Some Minutiae in the Treatment of the Lacrymal Passages, Tr. Pacific Coast Oto-Ophth. Soc. **4**:48, 1916.

Some Impressions of the Expression of Cataract with a Sliding Conjunctival Flap, Ann. Ophth. **25**:57, 1916.

The Biological Theory of Sympathetic Ophthalmia, Ophth. Rec. **25**:344, 1916.

The Desirability of Using Miotics as Adjuvants to Mydriatics, J. A. M. A. **67**:112 (July 8) 1916.

The Frequency of Occlusion of the Inner End of the Canaliculus in Old Trachoma, Ophth. Rec. **26**:462, 1917.

The Habitual Use of Spectacles as Insurance Against Traumatism, Ophth. Rec. **26**:519, 1917.

Some Personal Conclusions as to the Treatment of Senile Cataract, Wisconsin M. J. **17**:1, 1918.

Delimiting Keratotomy in the Treatment of Severe Corneal Ulcers, Tr. Am. Acad. Ophth. & Otol. **23**:418, 1918.

Blood Cyst of Orbit, Am. J. Ophth. **1**:625, 1918.

Rupture of Cornea by Contre-Coup from Bullet Wound of Orbit, Am. J. Ophth. **3**:787, 1920.

Sympathetic Ophthalmia, American Encyclopedia of Ophthalmology, 1920, vol. 16, pp. 12369-12417.

On Backing Out of Cataract Operations, Tr. Am. Acad. Ophth. & Otol., 1920, p. 171.

Molluscum Conjunctivitis (with S. R. Gifford), Arch. Ophth. **50**:227 (May) 1921.

Chalazion Technique, Am. J. Ophth. **6**:487, 1923.

The Treatment of Some Forms of Dermoid and Other Cysts with Trichloracetic Acid, Arch. Ophth. **52**:448 (Sept.) 1923.

Erysipelatous Necrosis of the Eyelids, Nebraska State M. J. **9**:447, 1924.

Miscellaneous Notes on Glaucoma, Arch. Ophth. **54**:337 (July) 1925.

Congenital Defects of Abduction and Other Ocular Movements and Their Relation to Birth Injuries, Am. J. Ophth. **9**:3, 1926.

Clinical Notes on Glioma of the Retina, Contributions to Ophthalmic Science, Menasha, Wis., George Banta Publishing Company, 1926, p. 63.

The Mitigation of Old Fogyism, Nebraska State M. J. **12**:339, 1927.

Nocturnal Lacrymation in Graves' Disease, Am. J. Ophth. **10**:922, 1927.

The Cause of Glaucoma of Hypermature Cataract, Arch. Ophth. **56**:457 (Sept.) 1927.

SALZMANN'S NODULAR CORNEAL DYSTROPHY

REPORT OF A CASE *

DEWEY KATZ, M.D.
CHICAGO

Nodular corneal dystrophy was first described by Groenouw in 1898. In 1925, Salzmann [1] reported twenty-three cases of a nodular form of corneal dystrophy which differed in several respects from Groenouw's nodular corneal dystrophy, but which, for want of a suitable distinctive and descriptive name, he called, "a variety of nodular corneal dystrophy." To date no additional case has been added to the literature. All cases studied by Salzmann and reported by him in the group just mentioned came under his observation after December, 1914, in the eye clinic of the University at Graz, Austria. It is significant that Salzmann did not see one such case during the many years he was associated with the eye clinic at the University of Vienna, although the number of patients seen in that clinic was much greater than that seen in the eye clinic of the University at Graz. It is also significant to note that Graz is approximately one hundred miles from Vienna. I saw a number of these cases while visiting the eye clinic of the University at Graz, and the case reported is typical of the group.

Marked elevation of the pathologic areas above the surface of the cornea is the most conspicuous characteristic of the lesion in the variety of nodular corneal dystrophy described by Salzmann. The prominences were usually round, occasionally conical or prismatic, and in elongated areas often wedgelike (fig. 1). The number of pathologic areas varied from one to eight and were bluish white. Some of the large and irregular prominences may have been due to the fusion of several smaller ones. No definite structure could be made out in the pathologic areas either with the Coddington loupe or with the slit-lamp, although occasionally one obtained the impression that fine white spots or even an indistinct netlike structure, was present. Examination of the cornea with axial illumination, Coddington loupe, slit-lamp and with the naked eye showed plainly the change in surface level. Whereas the usual maculae corneae almost permit the red reflex to show through them and are betrayed by a change in the fine shadow by a turn of the plano mirror, these areas on axial illumination are dark, almost black, the edges being almost as dark as the main mass.

---

* Submitted for publication, March 29, 1930.

* From the Department of Ophthalmology, University of Chicago.

1. Salzmann, M.: Ueber eine Abart der Knötchenförmigen Hornhautdystrophie, Ztschr. f. Augenh. **75**:92, 1925.

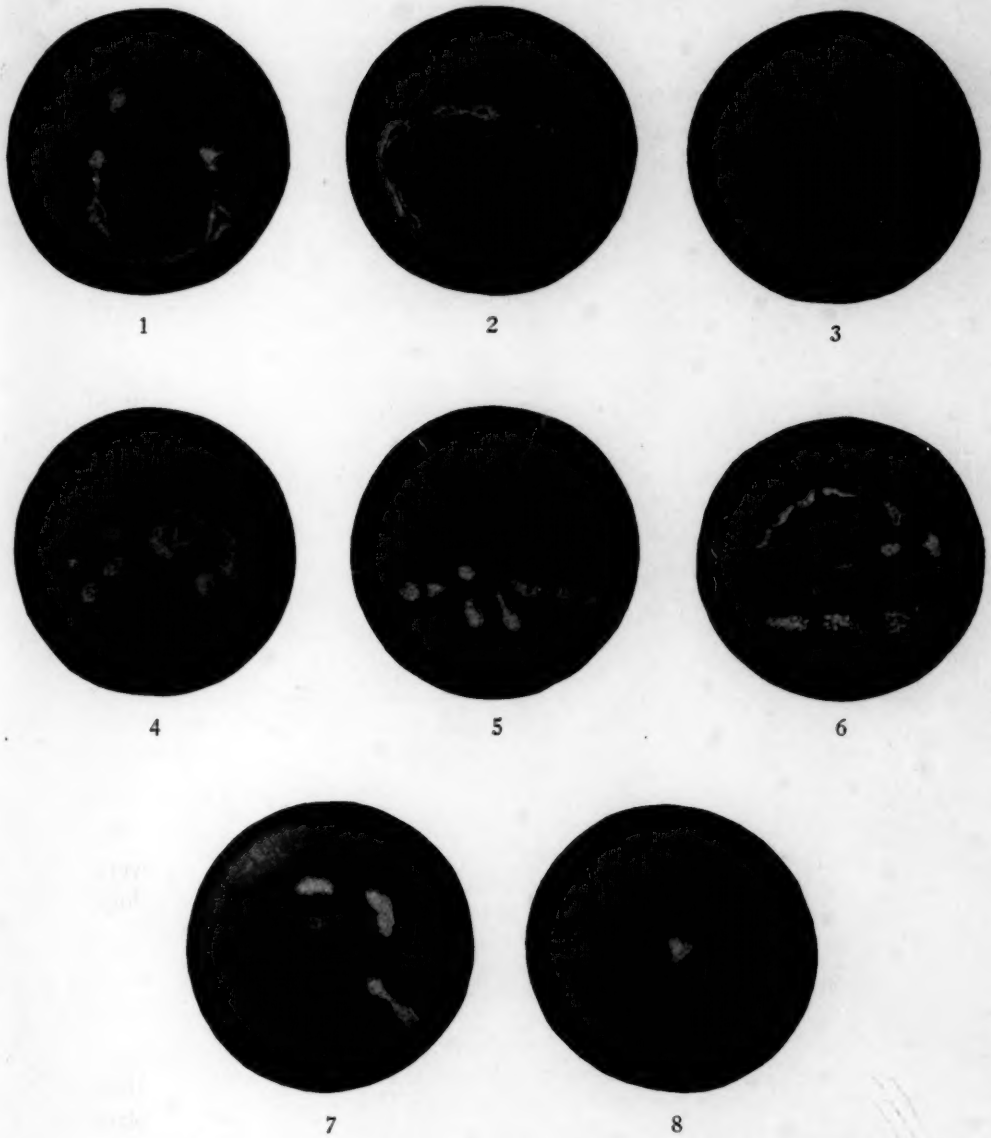


Fig. 1.—Some of Salzmann's cases (reproduced with permission of author and publisher). *1* shows left eye of E. E., aged 23, on Dec. 10, 1914; *2*, on Feb. 3, 1915; *3*, on April 3, 1919; *4*, left eye of B. B., aged 22, on April 3, 1919; *5*, left eye of J. B., aged 38, on Aug. 19, 1919; *6*, left eye of G. K., aged 46, on May 22, 1924; *7*, left eye of J. W., aged 64, on March 11, 1921, and *8*, left eye of L. G., aged 60, on Aug. 20, 1924.

In the twenty-three cases reported by Salzmann, eighteen occurred in females and five in males. The age range was from 12 to 64 years, but the condition was most frequently seen in persons between 15 and 30 and again in those between 45 and 55. In almost all instances the diseased eyes showed evidence of repeated attacks of eczematous keratoconjunctivitis either in the form of the usual corneal opacities or in the form of eczematous pannus. The number of eyes in which there was no evidence of eczematous keratoconjunctivitis were few. In three cases in which the pannus did not cover the entire cornea, the characteristic areas were at the edge of the pannus. Often enough the characteristic areas developed without irritative phenomena; the eyes at the time of the examination were white, diminution of visual acuity causing the patient to consult an oculist.

In eighteen of the twenty-three cases the characteristic lesions were one-sided, the fellow eyes having normal corneas or simple maculae corneae. In three of the remaining five cases, the areas were small and probably in the process of development at the time of observation. In the remaining two cases, the disease was equally severe in both corneas. Salzmann is of the opinion that at first the disease is always unilateral, but that there is a certain tendency for it to become bilateral.

Salzmann concluded that this condition could not be classified as an inflammation of the cornea, because of: (1) the complete absence of signs of irritation, (2) the slow but steady progress of the change and (3) the absence of a spontaneous process of involution in the completely developed pathologic areas. These facts necessitate the classification of the condition as a dystrophy of the cornea, and in this classification it simulates the corneal dystrophy of Groenouw. It differs from Groenouw's dystrophy in that: (1) the pathologic areas are larger and less numerous; (2) there are no small dystrophic areas between the large ones; (3) these areas are most frequently seen in the female sex; (4) the condition appears occasionally for the first time in the aged, and (5) these eyes nearly always show the result of an eczematous keratoconjunctivitis.

The usual therapeutic measures for such conditions, ethylmorphine hydrochloride and yellow mercuric oxide ointment, were of no avail. Salzmann cauterized one such area with an electric cautery. An extensive thick opacity with flattening of the cornea and a reduction of vision to counting of fingers at 2 meters was the unfortunate end-result of this procedure.

Salzmann removed a typical prominent dystrophic nodule in a patient, aged 60, with a keratome and examined the specimen histopathologically. Mechanical injury of the surface had produced a thinned epithelial layer. Bowman's membrane was absent. The superficial layers of the removed stroma were manifestly composed of old scar tissue.

The fixed cells were few and irregularly distributed. In the deeper layers irregular areas of corneal lamellae were heavily stained by the hematoxylin-eosin stain. Lamellae which took the normal hematoxylin-eosin stain were present between the more heavily stained areas. The bundles of lamellae were swollen and wavy and were obliquely situated. Strongly stained granules were present in this layer as well as in the adjacent deeper layers. The deepest layers of the excised piece appeared to be composed of normal corneal stroma.

The history and the clinical observations in the case reported are given.

REPORT OF CASE

History.—E. A., a white woman, aged 38, was admitted to the eye department of the University of Chicago on May 1, 1929. She gave a history of having had frequent recurrent attacks of "red eyes" accompanied by burning, itching, lacrimation, photophobia and occasional gluing together of the lids necessitating cleansing with hot boric acid to open them. Her mother stated that the first attack of "red eyes" occurred when the patient was 2 years of age. The patient was able to attend school for periods of from one to two weeks only and withdrew from school at the age of 12 because of the frequency of these attacks. She then sought medical treatment for the first time. Drops were prescribed, without improvement. When the patient was 14, the left eye turned in, and glasses were prescribed. Frequency and severity of the inflammatory attacks diminished with the onset of menstruation, but up to this time there had never been a period when both eyes were absoultely free from signs and symptoms of inflammation. During the fifteen to sixteen years following the onset of menstruation, the symptoms were mild. At about the age of 32, the patient began to have severe attacks of inflammation in both eyes with injection, lacrimation and photophobia. The recurrences occurred about from every four to six months over a period of two years. The duration of each attack varied from several weeks to three months. During the past four years the right eye only had been involved. Atropine, hot applications and other drugs were used during these attacks. Medical examination for a focus of infection and examinations of the blood gave negative results. A few suspicious teeth (x-ray picture) were extracted, with no improvement. Neither distant vision nor near vision had been impaired during the past six years.

Examination.—The present attack began one and one-half months previous to examination and involved the right eye only. The patient complained of injection, lacrimation, photophobia and "drawing sensation." The observations were: vision in the right eye was 0.4—1; following instillation of homatropine, it was + 2.50; with + 0.75 cylinder axis 60 it was 1.2 + 2. Vision in the left eye was 0.4; following instillation of atropine it was + 2.00; with + 2.25 cylinder axis 90 it was 0.4. The left eye converged 10 degrees (perimeter method) without glasses and 8 degrees with correction. There was good central fixation with each eye and no limitation of ocular movements. Normal retinal correspondence was present when tests were made with the Hering lamp.

Examination of the right eye showed the skin of the lower lid to be moist and eczematous; the margins of the lid were red and the cilia were matted together by lacrimation into groups of from three to five, all having normal direction. The lower palpebral conjunctiva was diffusely reddened and hypertrophied; the fornix conjunctiva was thickened and brownish gray (argyrosis), and this discoloration

extended on the scleral conjunctiva for a few millimeters. The upper palpebral conjunctiva was normal. The anterior ciliary vessels were moderately dilated, and a faint circumcorneal ciliary blush from 2 to 9 o'clock was present. Superficial vessels crossed the limbus from 3 to 7 o'clock and extended into the cornea for a distance of 2 mm. Those crossing the limbus at 4 o'clock passed to a *grayish-white, prominently elevated area, irregularly square in outline and about 1.5 mm. in diameter,* located over the pupillary margin of the iris at 5 o'clock, the pupil being from 3 to 3.5 mm. in width. With both the Coddington loupe (fig. 2) and the slit-lamp (fig. 3), even with oblique illumination, the elevated area

Fig. 2.—Dystrophic nodule as seen with the Coddington loupe (painting by Dr. Bertha Klien).

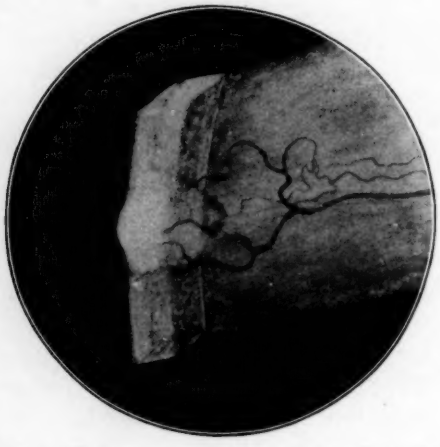


Fig. 3.—Dystrophic nodule as seen with the slit-lamp (painting by Dr. Bertha Klien).

was seen passing almost directly forward from the cornea, and its prominence above the surface was marked. In depth, it extended through about the outer one half of the cornea, broadening out into a sort of truncated base. This pathologic mass was composed of a chalky white center and a peripheral portion that was grayish white. With axial illumination this nodular portion of the cornea gave a coal black reflex when examined from directly in front or from the sides. The vessels crossing the limbus at 4 o'clock extended into the superficial layers of the cornea up to the temporal side of the opaque mass, three branches reaching almost to its center. There were numerous superficial faint grayish opacities, varying in size from that of a pinpoint to that of a pinhead, in the superficial

layers of the lower half of the cornea. Fluorescein did not stain any area in the cornea. The rest of the media, the iris, disk and tactile tension were normal.

Examination of the left eye showed the margin of the lid to be hyperemic. The lower palpebral conjunctiva was diffusely reddened and slightly thickened. The fornix conjunctiva was brownish red, and the lower half of the bulbar conjunctiva was a dirty grayish white. There were several small, superficial, faint, grayish opacities together with a pannus 2 mm. wide in the lower portion of the cornea. No area was stained by fluorescein. The iris, disk and tactile tension were normal.

The Mantoux test for tuberculosis was negative. The Wassermann and the Kahn tests of the blood were negative. The blood pressure was 150 systolic and 90 diastolic. The white blood count was 7,000; the red blood count, 4,500,000. Urinalysis was negative. Clinical and roentgen examinations of the chest gave negative results. The tonsils were reported to be infected. The rest of the physical examination was negative. The patient stated that she ate sparingly of meat, fish, chicken and eggs and that she drank little milk.

Treatment.—Therapeutically, mercury was employed in the right eye in the form of mild mercurous chloride insufflation, mercuric oxycyanide (1:3,000), 1 drop three times a day, and yellow mercuric oxide ointment (3 per cent), nightly. The existing recurrent inflammatory attack was aborted. This treatment was carried out rather faithfully, and when the patient was seen on August 30, the conspicuously elevated portion was flatter than when first examined, and only one vessel could be seen entering the opaque mass. The intense black reflex was still to be seen when the cornea was examined by axial illumination.

COMMENT

The condition in this case simulates that in the cases reported by Salzmann in that (1) it is present in a woman who has suffered from recurrent attacks of eczematous keratoconjunctivitis; (2) it is unilateral, and (3) the nodular dystrophic area has an abrupt and conspicuous projection forward from the surface of the cornea and gives a black reflex throughout on axial illumination. It differs from the condition in Salzmann's cases in that it has caused no reduction in vision, due to its location, and there has been a slight regression in the prominence of that portion extending forward from the cornea.

There can be no doubt that this type of corneal dystrophy is more common than only these two reports on the subject would lead one to believe, especially in view of the fact that Salzmann's group of cases were from Graz and its surroundings, and this case was seen in Chicago. This corneal dystrophy is clinically, pathologically and etiologically different from the group known as Groenouw's nodular corneal dystrophy and should not be classified with it. In view of the fact that the dystrophy described appears to be a separate clinical entity, I have named it after the original investigator to whom ophthalmologists are indebted for the knowledge of this condition, "Salzmann's nodular corneal dystrophy."

THE MEASUREMENT OF THE LIMBUS IN CHINESE EYES *

W. P. LING, M.D.
PEIPING, CHINA

The limbus is one of the interesting and important clinico-anatomic landmarks of the eyeball. The description of its boundaries found in most of the ophthalmic textbooks and literature is generally not uniform. Salzmann [1] defined the limbus as "the transitional zone between the cornea proper on one side and the adjacent tissues (conjunctiva and sclera) on the other, it being a zone of 1 mm. width limited centrally by the margin of Bowman's membrane and peripherally by the corneoscleral border, and, properly speaking, including only the anterior layers (?) of the cornea. It may be thought of as being bordered by a plane going through the depths of the cornea from the border of Bowman's membrane to the border of Descemet's membrane." This represents, it seems, only that part of the limbus which is clinically visible. These definitions in the English translation are not clear; unfortunately, the German edition is not available.

Le Magourou's [2] definition of the limbus seems rational and practical and will be followed in this paper. According to him, the limbus may be regarded as consisting of two parts (fig. 1), pure scleral (posterior) and mixed sclerocorneal (anterior), both of which together form the main part of the anterior wall of the filtration angle. The first or scleral part, between the levels of the scleral spur and the end of Descemet's membrane, is entirely opaque and is connected with Schlemm's canal. This may be called the "filtration zone." The second or corneoscleral part is formed by tissues that are partly opaque (sclera) and partly transparent (cornea), in approximately equal proportions. It corresponds to the corneal and scleral "bevels" which fit into each other at a plane represented by a line connecting the borders of Bowman's and Descemet's membrane (fig. 1). The corneal bevel is formed at the expense of its external layers, while the scleral bevel is formed at the expense of its internal layers. It is because of these

* Submitted for publication, March 19, 1930.

* From the Department of Ophthalmology, Peiping Union Medical College.

1. Salzmann: The Anatomy and Histology of the Human Eyeball in the Normal State, Its Development and Senescence, translated into English by Dr. E. V. L. Brown, Chicago, Chicago Medical Book Company, 1912, pp. 38 and 39.

2. Le Magourou: De l'anatomie topographique du limbe scléro-cornéen de la meilleur procédé pour faire une sclerectomie, Arch. d'opht. **34**:85, 1914.

anatomic peculiarities that in dissecting the bulbar conjunctiva from the sclera up to the corneal margin, one sees in the region of the limbus first an entirely opaque tissue and then a semitransparent tissue. Only the corneoscleral part of the limbus is covered posteriorly by the endothelium (?).

Le Magourou stated that from the physiologic as well as from the anatomic point of view the sclerocorneal section of the limbus serves

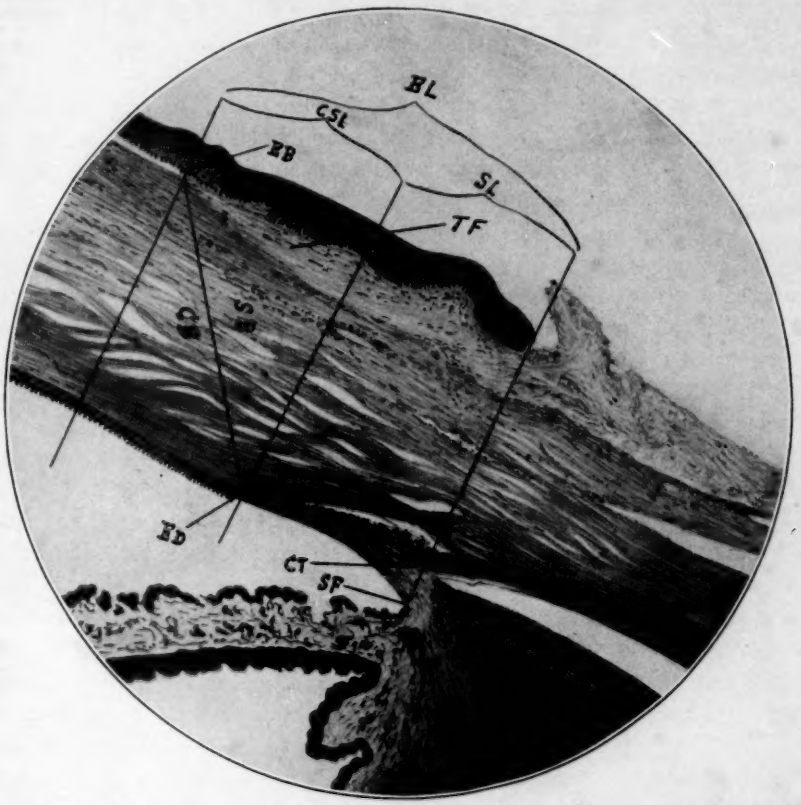


Fig. 1.—Extent and details of the limbus. *EL* indicates the entire length of the limbus; *CSL*, the corneoscleral part of the limbus; *SL*, scleral part of the limbus ("filtration zone"); *EB*, end of Bowman's membrane (the corneal border of the clinically visible limbus); *ED*, end of Descemet's membrane; *SB*, scleral bevel; *CB*, corneal bevel; *CT*, tendon of the ciliary muscle at the scleral roll; *SF*, summit of the filtration angle; *TF*, triangular area of fibrous tissue, the anterior limit of which usually corresponds to *EB*. The ends of Bowman's and Descemet's membrane are drawn more distinctly than seen in the actual sections in order to bring out more clearly the details concerned.

merely as a protective structure for the region, whereas the scleral is concerned in the excretion of the intra-ocular fluids. Both parts are covered externally by the bulbar conjunctiva, which is a continuation

of the corneal epithelium and Bowman's membrane. The epithelium of the bulbar conjunctiva in this region is separated from the underlying sclerocorneal tissue by a network of loose and plane fibrous tissue. This fibrous tissue continues posteriorly into Tenon's capsule, but anteriorly it gradually diminishes in thickness toward the cornea until it finally disappears at the corneal margin. Salzmann [1] described this tissue as "the area occupied by the marginal vessel loops, which shows, on meridional section, the form of a triangle with its apex at the border of Bowman's membrane and its base continued into the conjunctiva, sclera, and the episcleral tissue."

These anatomic features are briefly mentioned because of their importance in connection with the measurement of the limbus by previous authors like Le Magourou and others, as described below. They are shown somewhat diagrammatically in figure 1.

As pointed out by Le Magourou, from the standpoint of operation in this region, such as La Grange's sclerotomy, Elliot's trephining, anterior sclerotomy and iridectomy, the determination of the width of the limbus is of some importance in individual cases, particularly with a view to ascertaining the situation of the ciliary body and the location of the filtration angle. An exact measurement of the extent of the limbus is indicated for this purpose.

Rochon-Duvigneaud,[3] as early as 1892, was the first to undertake measurement of this sort, but merely for anatomic interest. He chose two points between which the measurement was taken: (1) the limbal border on the cornea visible to the naked eye, and (2) the "iridocorneal" angle (he did not mention definitely what place of this angle). His figures of the measurement were as follows: The distance between the limbal border on the cornea and the "iridocorneal" angle was 2.25 mm. for the superior end of the vertical meridian, and 2 mm. for the inferior end of the same meridian. The figure for the horizontal meridian was 1.25 mm. (on both sides?).

Later other authors, as Testut, Jacob, Poirier, Charpy and Ducamp, made similar investigations. Much more exact measurements were subsequently made by Le Magourou,[2] who undertook both macroscopic and microscopic measurements.

The macroscopic measurement was between the extreme limit to which the bulbar conjunctiva could be detached from the sclera up to the corneal margin on the one hand, and the tendon of the ciliary muscle on the other.[4] He made the measurement on twenty eyes from cadavers in both the vertical and the horizontal meridians. In the vertical

3. Rochon-Duvigneaud: Recherches anatomiques sur l'angle de la chambre anterieure et le canal de Schlemm, Arch. d'opht. **12**:732, 1892; **13**:20 and 108, 1893.

4. He did not mention clearly at what point of the ciliary tendon he measured, presumably at the scleral roll.

meridian he found that the figure averaged 1.75 mm. for the superior end, and 1.45 mm. for the inferior end. The highest figure for the superior end was 2.5 mm., and the lowest, 1.5 mm. The highest figure for the inferior end was 1.75 mm., and the lowest, 1.25 mm. In the horizontal meridian, the figure amounted to an average of 1 mm. for both the temporal and the nasal end.

The microscopic measurement was between the point where the fibrous tissue, continued from Tenon's capsule, ceases under the bulbar conjunctiva at the corneal margin on the one hand,[5] and the tendon of the ciliary muscle on the other. In the vertical meridian, he found an average of 1.763 for the superior end and 1.315 for the inferior end. He did not mention the figure for the horizontal meridian.

The results obtained by these two methods were in close agreement with one another.

As to the corneal or scleral "bevel," i. e., the distance between the borders of Bowman's and Descemet's membrane, he found that in the vertical meridian it amounted to an average of 1 for the superior end and 0.8 mm. for the inferior end.

The extent of the scleral part of the limbus, which corresponds to the "filtration zone," was found to be 0.75 mm. for the superior end of the vertical meridian and 0.65 mm. for the inferior end of the same meridian. In his opinion, such an operation as sclerectomy should be done in this "filtration zone," so as to avoid injury both to the ciliary body and to the cornea proper.

On the basis of these results, Le Magourou concluded that the width of the limbus varies very much in different people and causes the variation in the depth of the filtration angle.

EXPERIMENTAL DATA

All the measurements made by these authors were performed on European eyes. It is of interest to find what relations exist under the same conditions in Chinese eyes, and for this purpose the accompanying tables have been prepared embodying the results of microscopic measurement on twenty-three eyes from cadavers.

These eyes were prepared in the usual way with the ordinary fixation fluids, and, whenever possible, sections were made in the two principal meridians, vertical and horizontal. They were stained either with hematoxylin and eosin or with van Gieson's stain.

The technic of the measurement explains itself in figure 2. It is based on the definition of limbus given by Le Magourou (fig. 1).

Before discussing the tables, a few words of explanation seem necessary with regard to the material used for this investigation. The twenty-three eyes were all obtained at autopsy. Actually, a much larger

5. This presumably corresponds to the end of Bowman's membrane.

number of eyes was obtained than is represented by the present material, but unfortunately the majority of them were unfit for my purposes because some of the landmarks essential for the measurement are for one reason or another too indefinite and difficult to be made out. The number available is therefore reduced to twenty-three, in which the landmarks are, in the majority of cases, sufficiently clearcut to make the measurement possible.

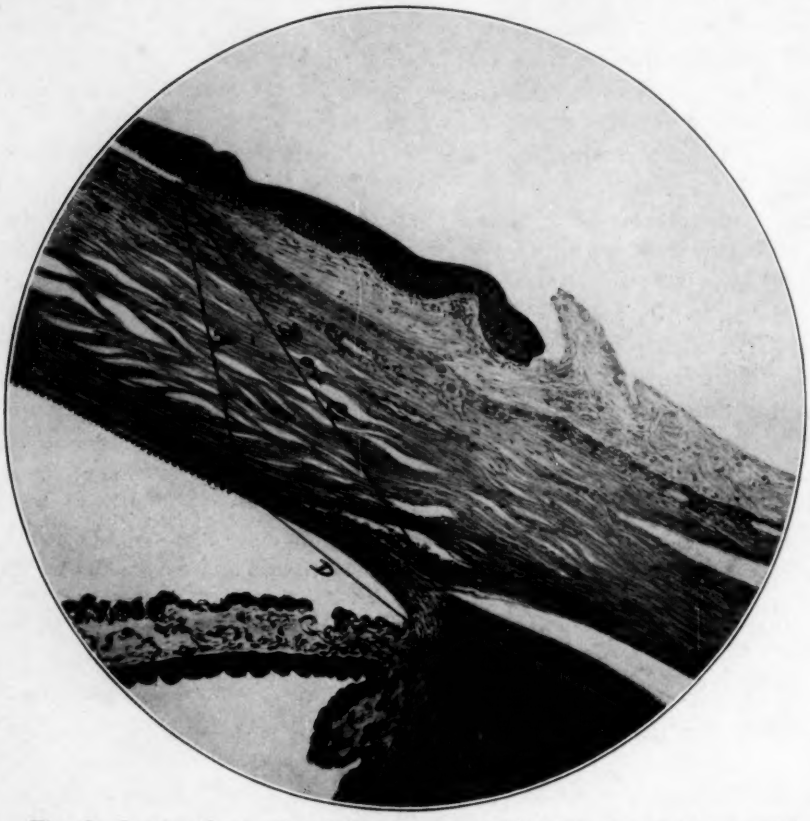


Fig. 2.—Landmarks in the limbus between which measurements are made. *A* indicates the measurement between the ends of Bowman's and Descemet's membrane; *B*, measurement between the end of Bowman's membrane and the ciliary tendon at the scleral roll; *C*, measurement between the anterior limit of the fibrous tissue beneath the bulbar conjunctiva and the ciliary tendon at the scleral roll; *D*, measurement between the summit of the filtration angle and the end of Descemet's membrane. *B* and *C* usually, but not necessarily, correspond with each other.

Even in this material a few difficulties of this nature have been encountered. Thus, in a few instances, it is not possible to say with certainty that the fibrous layer beneath the bulbar conjunctiva ends at

the border of Bowman's membrane, as is usually seen in sections and accepted to be the case in standard textbooks. That kind of uncertainty is observed in case 1 (table 1) and in a few others (fig. 3) in which this fibrous layer seems to have its limit placed a little behind the end of Bowman's membrane. The limit of the fibrous layer, according to Le Magourou, is apparently the extreme point at which the bulbar conjunctiva can be dissected from the corneoscleral tissue without tear-

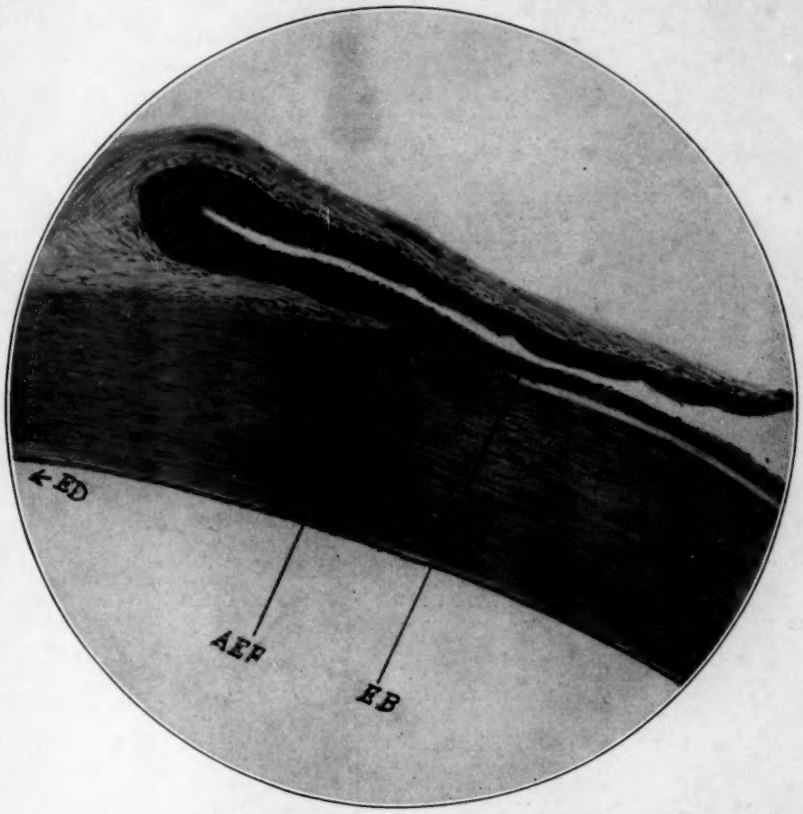


Fig. 3.—In this particular case the end of Bowman's membrane and the anterior limit of the fibrous tissue beneath the bulbar conjunctiva do not seem to meet as is usually the case. *EB* indicates the end of Bowman's membrane; *AEF*, the apparent end of the fibrous tissue; *ED*, end of Descemet's membrane.

ing, but for obvious reasons this method of determination is also open to objection.

Furthermore, the summit of the filtration angle is occasionally not as definite as one at first thinks. For example, in front of what is believed to be the summit of the filtration angle there may be a few festoon-like fibers bridging the space between the root of the iris and

TABLE 1.—*Measurements of the Limbus**

Case	Age	Sex	Meridians	Measurements in Millimeters A	B	C	D
1	42	F	VS (R)....No material†				
			(L).....	2.331	3.330	3.330	0.999
			VI (R).....	2.279	3.103	3.103	1.053
			(L)....No material				
			HT (R).....	1.931	2.604	2.170 (?)‡	0.911
			(L)....No material				
			HN (R).....	1.397	2.213	1.541 (?)	0.868
			(L)....No material				
2	26	F	VS (R).....	1.931	2.561	2.561	0.738
			(L)....No material				
			VI (R)....No material				
			(L)....No material				
			HT (R).....	1.042	1.289	1.289	0.760
			(L).....	1.237	1.845	1.845	0.846
			HN (R).....	1.128	1.259	1.259	0.586
			(L).....	1.172	1.823	1.823	0.760
3	19	M	VS (R)....No material				
			(L)....No material				
			VI (R).....	1.280	2.344	2.170 (?)	1.736
			(L).....	1.085	2.062	2.062	1.085
			HT (R).....	0.911	1.845	1.736 (?)	1.354
			(L).....	1.639	2.724	2.713 (?)	1.628
			HN (R).....	1.085	1.953	1.801 (?)	1.497
			(L).....	0.911	1.888	1.714 (?)	1.584
4	New-born	M	VS (R).....	1.628	2.427	2.396 (?)	0.535
			(L)....No material				
			VI (R).....	1.085	1.584	1.584	0.651
			(L).....	0.890	1.250	1.250	0.477
			HT (R).....	1.020	1.020	0.911 (?)	0.521
			(L).....	1.280	1.801	1.801	0.651
			HN (R).....	0.868	1.063	0.977 (?)	0.760
			(L).....	0.911	1.215	0.911 (?)	0.738
5	15 mo.	F	VS (R).....	1.085	1.953	1.953	1.085
			(L).....	1.237	1.953	1.953	0.803
			VI (R).....	0.521	1.311	1.311	1.085
			(L).....	0.901	2.799	2.799	1.063
			HT (R)....No material				
			(L)....No material				
			HN (R)....No material				
			(L).....	0.760	1.194	1.194	0.977
6	12	F	VS (R).....	2.539	3.364	3.364	1.237
			(L).....	1.996	3.147	3.147	1.389
			VI (R).....	1.250	2.279	2.279	1.519
			(L).....	1.237	2.170	2.170	1.267
			HT (R).....	1.388	2.220	2.220	1.221
			(L)....No material				
			HN (R).....	1.845	2.496	2.496	0.963
			(L).....	1.020	1.823	1.823	1.042

* In the tables A indicates the distance between the ends of Bowman's and Descemet's membrane (fig. 2); B, distance between the tendon of the ciliary muscle at the scleral roll and the end of Bowman's membrane (fig. 2); C, distance between the tendon of the ciliary muscle at the scleral roll and the limit of the fibrous tissue beneath the bulbar conjunctiva at the corneal margin (fig. 2); D, distance between the summit of the filtration angle and the end of Descemet's membrane ("filtration zone") (fig. 2). VS indicates the vertical meridian, superior end; VI, vertical meridian, inferior end; HT, horizontal meridian, temporal end; HN, horizontal meridian, nasal end; (R), right eye; (L), left eye.

† By no material is meant either that: (1) the material is not available or (2) the material is not suitable for the measurement.

‡ The figures followed by a question mark indicate that in these measurements the anterior limit of the fibrous tissue beneath the bulbar conjunctiva is not as definite as in most of the cases and seems to be behind the end of Bowman's membrane.

TABLE 1.—*Measurements of the Limbus—Continued*

Case	Age	Sex	Meridians	Measurements in Millimeters A	B	C	D
7	New-born	M	VS (R).....	1.085	1.628	1.629	0.760
			(L).....	1.085	1.714	1.714	0.708
			VI (R).....	0.846	1.259	1.259	0.738
			(L).....	0.911	1.234	1.224 (?)	0.651
			HT (R).....	0.781	0.868	0.868	0.564
			(L).....	1.042	1.150	1.150	0.868
			HN (R).....	0.911	1.042	1.042	0.868
			(L).....	0.803	0.911	0.911	0.564
8	4	M	VS (R)....No material				
			(L)....No material				
			VI (R).....	1.389	2.170	2.170	1.085
			(L)....No material				
			HT (R).....	0.933	1.476	1.476	1.085
			(L)....No material				
			HN (R).....	0.911	1.376	1.376	0.977
			(L)....No material				
9	24	M	VS (R).....	1.801	2.604	2.604	0.846
			(L).....	2.105	2.799	2.799	0.825
			VI (R).....	1.519	2.387	2.387	1.085
			(L)....No material				
			HT (R).....	0.846	1.584	1.584	1.042
			(L).....	1.280	2.170	2.170	0.955
			HN (R).....	0.738	1.484	1.484	1.107
			(L).....	1.085	1.856	1.736 (?)	0.890
10	31	M	VS (R)....No material				
			(L)....No material				
			VI (R).....	1.410	2.062	2.062	0.846
			(L)....No material				
			HT (R).....	1.205	1.714	1.714	0.608
			(L).....	1.085	1.562	1.562	0.738
			HN (R).....	1.085	1.541	1.411 (?)	0.651
			(L)....No material				
11	18 days	M	VS (R).....	0.846	1.194	1.194	0.456
			(L)....No material				
			VI (R)....No material				
			(L).....	0.781	1.194	1.194	0.664
			HT (R).....	1.085	1.419	1.419	0.608
			(L).....	0.803	1.085	0.933 (?)	0.651
			HN (R).....	0.543	0.825	0.758 (?)	0.543
			(L).....	0.651	1.085	0.988 (?)	0.598
12	30	M	VS (R)....No material				
			(L)....No material				
			VI (R).....	1.801	2.716	2.716	0.868
			(L).....	1.215	2.127	2.127	1.128
			HT (R).....	0.933	2.865	2.799 (?)	1.085
			(L).....	0.803	2.713	2.539 (?)	1.128
			HN (R).....	0.846	2.864	2.582 (?)	1.042
			(L).....	0.803	2.843	2.626 (?)	1.128

the pectinate ligament. One may perhaps just as well regard this point as the actual summit of the filtration angle.

The figures in table 1 for both eyes vary a great deal with respect to *A, B, C* and *D* in the different ends of the two meridians. Without regard to age and sex, the two extreme figures for each are as given in table 2.

When the numerous seemingly confusing figures in table 1 are averaged, table 3 is obtained, which shows more clearly the differences in the width of the limbus in the different ends of the two meridians in both eyes, and which may be used for direct comparison with the results obtained by Magourou.

TABLE 2.—*Extreme Figures for Each Meridian*

		A	B	C	D
VS (R)	Highest	2.539	3.364	3.364	1.237
	Lowest	0.846	1.194	1.194	0.456
(L)	Highest	2.331	3.330	3.330	0.999
	Lowest	1.085	1.714	1.714	0.803
VI (R)	Highest	2.279	3.103	3.103	1.736
	Lowest	0.521	1.311	1.311	0.651
(L)	Highest	1.237	2.709	2.709	1.267
	Lowest	0.781	1.194	1.194	0.477
HT (R)	Highest	1.931	2.865	2.799 (?)	1.354
	Lowest	0.846	0.868	0.868	0.521
(L)	Highest	1.639	2.724	2.713 (?)	1.628
	Lowest	0.803	1.085	0.933 (?)	0.651
HN (R)	Highest	1.845	2.864	2.582 (?)	1.497
	Lowest	0.738	1.042	0.977 (?)	0.586
(L)	Highest	1.172	2.843	2.626 (?)	1.584
	Lowest	0.651	0.911	0.911	0.564

TABLE 3.—*Average Measurements of the Limbus in All Ages and Both Sexes*

Number of Eyes Measured	Meridians	Measurements in Millimeters			
		A	B	C	D
7	VS (R)	1.559	2.247	2.242	0.808
5	(L)	1.750	2.588	2.588	0.944
10	VI (R)	1.338	2.121	2.104 (?)	1.066
7	(L)	1.000	1.835	1.835	0.905
11	HT (R)	1.097	1.719	1.653 (?)	0.887
8	(L)	1.146	1.881	1.839 (?)	0.933
10	HN (R)	1.081	1.739	1.612 (?)	0.928
9	(L)	0.901	1.626	1.525 (?)	0.920

CONCLUSIONS

Although the foregoing tables are self-explanatory, and can readily be compared with the results of Le Magourou quoted in the beginning of the paper, a few general conclusions may be pointed out, as follows.

1. Compared with the observations of Le Magourou, the limbus in Chinese eyes is wider on the average than that in European eyes. This shows itself in all the measurements, namely, *A*, *B* or *C* and *D*. It seems to confirm the clinical observation of Pillat,[6] who was impressed

6. Pillat: The Exaggeration of the Upper Limbus in Sickle-Form in Chinese Eyes, Nat. M. J. China **15**:569, 1929.

with the unusually wide limbus in some Chinese eyes. The fact that Chinese eyes have a rather wide limbus, especially in the vertical meridian, carries with it a practical significance. When performing an iridectomy on such eyes, for example, one should not enter the point of a keratome too close to the corneal border of the clinically visible limbus, because in so doing one is usually too far away from the filtration angle. Of course, it is not possible to lay down any hard and fast rule as to how many millimeters away from the central border of the limbus one should place the knife, since the width of the limbus varies a great deal in different persons, but if the fact that the Chinese eyes have a relatively wide limbus is not kept in mind the depth of the filtration angle may be underestimated.

2. According to the few cases examined, age and sex do not seem to have any importance in determining the width of the limbus. A newborn infant, for example, may have just as wide a limbus as an adult.

3. The width of the limbus varies considerably in different persons, as in European eyes (table 2).

4. The limbus is wider in the vertical than in the horizontal meridian, and widest in the superior end of the vertical meridians. Generally speaking, the limbus in the left eye tends to be wider than that in the right eye.

5. It remains a possibility that the limbus in these eyes was actually wider during life than indicated by my measurements, because it is reasonable to assume that the process of fixation, etc., may have brought about enough shrinkage to influence the measurement to some extent.

CYCLIC OR RHYTHMIC OCULOMOTOR PARALYSIS*

ELIAS SELINGER, M.D.
CHICAGO

Careful search of the literature revealed only twenty-eight cases of this rare and interesting disease. The case reported is the twenty-ninth of the series, and as far as could be learned is the first to be described in the American literature.

REPORT OF CASE

J. O., a well developed white boy, aged 16, came to the eye department of Rush Medical College on Dec. 12, 1929, complaining of right-sided ptosis, inability to see with the right eye and right divergence, symptoms which had been present since birth. The patient had two older brothers and a younger one, all apparently well. His mother had been an inmate of an insane asylum since the birth of his younger brother, twelve years previously.

General physical examination revealed a 4+ Wassermann reaction of the spinal fluid, a negative Wassermann reaction of the blood and Hutchinson's teeth. The results of the neurologic examination were negative, except for the changes in the eye to be described, and psychiatric examination showed the intelligence quotient to be 71. The patient had been given antisyphilitic treatment from April 4 to June 26, 1928, at another institution, and was given the same treatment here. He stated that he had had two or three operations in childhood for correction of the squint and ptosis, but no data on this could be obtained as his mother was insane, the father lived out of town and refused to answer written inquiries, and the whereabouts of other relatives were unknown.

Vision in the right eye was 3/200, fixation being eccentric; in the left eye, 20/20 + 3 unaided. The left eye was normal. The changes found in the right eye were those of an incomplete paralysis of all the branches of the oculomotor nerve and are best described in two stages. In the first or flaccid stage, the upper lid drooped so that the palpebral fissure was narrowed to 3 mm.; the eye deviated outward, the squint angle being from 40 to 45 degrees, as measured with a perimeter, and the pupil was dilated to 8 mm. This stage lasted about twenty seconds and was followed by a second or spastic stage in which the outer half of the right eyebrow moved up, causing a wrinkling of the skin on that side of the forehead; the upper lid elevated in a jerky manner until the palpebral fissure was from 8 to 9 mm. wide, and what must have been a spasm of the internal rectus moved the eyeball nasalward so that the squint angle diminished from 5 to 8 degrees at the same time that the pupil rapidly contracted to 3 mm. This stage lasted from fifteen to twenty seconds and was followed again by the flaccid stage. The process of dilatation took from twenty to twenty-five seconds; contraction, twenty seconds. The entire cycle required about from sixty to eighty seconds and was constantly repeated. The spastic phenomena were executed more rapidly than the flaccid. With the pupillary changes there was an alternating spasm of the ciliary muscle, as evidenced by a change of 3.5 diopters

* Submitted for publication, March 20, 1930.

between the contraction and the dilatation stage of the pupil, as observed by retinoscopy.

Light, effort at convergence and accommodation and effort at elevation and depression of the gaze had no effect during the contraction stage and caused only a momentary twitching of the iris and eyelid during relaxation. A pseudo-Graefe sign was present in the spastic stage; i. e., when the patient was asked to look down, the right upper lid remained elevated. Voluntary movements consisted of good abduction and poor adduction. There was nasal rotation of the cornea on effort to look down. The abducens and trochlear nerves were therefore not involved. The eyeball could not be elevated. The caruncle and plica semilunaris were prominent and displaced forward, possibly due to previous operation.

A, ptosis of the right upper lid during the flaccid stage. *B*, pseudo-Graefe sign, present in the spastic stage. The right upper lid remains elevated while the patient looks down. *C*, beginning of flaccid stage—the right pupil is partially dilated.

The application of 2 per cent pilocarpine caused a contraction of the pupil to 2.5 mm. with no alteration in size, while the lid and adduction phenomena continued as before. While the pupil was contracted, the patient complained of pain in the right eye, the pain being rhythmic and most severe during what would correspond to the spastic stage of the cycle of the ciliary muscle. Homatropine dilated the pupil to 8 mm. and abolished the pain, but had no influence on the changes of the lid and rectus medialis. The right pupil did not react consensually, as did the left. Peripheral visual fields for form and color were normal, and there were no central scotomas. The fundus showed no pathologic changes.

REVIEW OF THE LITERATURE

Rampoldi,[1] in 1884 and 1886, published two cases; Fuchs,[2] in 1893, added one, and Axenfeld and Schürenberg,[3] in describing their case in 1901, called attention to the fact that all of the cases published had in common paresis or paralysis of the extrinsic as well as of the intrinsic branches of the oculomotor nerve, with a cyclic or rhythmic spasm of the muscles supplied by the intrinsic and some of the extrinsic branches. They pointed out that this group of cases formed a definite clinical entity, and suggested the name "cyclic congenital oculomotor disease." Since then it has been found that of twenty-nine cases, fifteen were congenital, eight developed during the first year of life and six developed at a later age. Greeves [4] reported the case of a girl, aged 8, who developed the syndrome at the age of 7 years following an attack of measles, while in Salus' [5] patient the onset was at the age of 5 years and followed suppurative cervical adenitis. Bielschowsky,[6] in reporting four additional cases—his first report appearing in 1903—pointed out that the cyclic phase may not appear until months or years after there has been a definite oculomotor paralysis. This seems to be confirmed by the case described, if the patient's statement that after the first course of antisyphilitic treatment he could open his eyes while prior to this he could not can be interpreted as meaning that the elevation of the lid he has reference to is synonymous with spasm of the levator palpebrarum.

That this condition is extremely rare is shown by the fact that among 1,700 cases of paralysis of the ocular muscles Bielschowsky [7] found only five cases. Rampoldi, Franke [8] and Krämer [9] each described two cases, one of Rampoldi's cases being unusual in that both eyes were involved, one eye being in the flaccid stage while the other was in the spastic stage, thus producing a constant see-saw movement. Eighteen of the twenty-seven cases in which the sex was given occurred in females. One oculomotor nerve is affected about as often as another. In three cases there was also involvement of the fourth nerve, and in Lauber's [10] case the fifth nerve on the same side and the seventh and ninth on the opposite side were paretic. One patient had an abducens weakness, but

1. Rampoldi: Ann. oftal. **13**:463, 1884; **15**:54, 1886.
2. Fuchs, E.: Beitr. z. Augenh., 1893, vol. 11.
3. Axenfeld and Schürenberg: Klin. Monatsbl. f. Augenh. **39**:64, 1901.
4. Greeves, R. A.: Proc. Roy. Soc. Med. **6**:23, 1913.
5. Salus, R.: Klin. Monatsbl. f. Augenh. **50**:66, 1912.
6. Bielschowsky, A.: Klin. Monatsbl. f. Augenh. **40**:308, 1903.
7. Bielschowsky, A.: Arch. f. Ophth. **121**:659 (March) 1929.
8. Franke, E.: Klin. Monatsbl. f. Augenh. **47**:582, 1909.
9. Krämer: Ztschr. f. Augenh. **29**:77, 1913.
10. Lauber: Wien. klin. Wchnschr. **26**:707, 1913.

this might have been due to an old tenotomy on the external rectus. The pupil participated in all cases in the cyclic changes, the levator palpebrarum in twenty-one of twenty-nine cases and the ciliary muscle in eleven of the sixteen cases examined for that symptom. The involvement of the extrinsic eye muscles is less frequent and less severe. Of these muscles, the internal rectus is the one most commonly affected, thirteen times. The spastic features have been observed to continue during sleep. In two cases there was ocular nystagmus, in one of these bilateral; in both cases the good eye was affected. Amblyopia is a noteworthy symptom. Of eighteen patients in whom a functional examination was reported, fourteen showed much poorer vision in the unaffected eye than in the other eye. The impairment of vision is probably on the basis of an amblyopia exanopsia, although vision in the affected eye remained good even in some of the congenital cases.

Axenfeld and Schürenberg compared the spasm to athetoid movements, but in these voluntary movements are reestablished at the time of the appearance of the athetoid motions. Fromaget [11] reported his case as "hippus ou athetose pupillaire," and Aurand and Breuil [12] likewise reported theirs as hippus. Bach, in defining hippus, stated that it is a rhythmic narrowing and widening of the pupil, appearing on the average of every one to three seconds, the excursions being approximately equally large, usually from 2 to 3 mm., and independent of illumination, convergence and psychic and sensory stimulation.

As no case has come to autopsy, the nature and location of the lesion are based on theory rather than on pathologic observations. E. Fuchs and others thought that there is a nuclear lesion, while Mosso [13] expressed the belief that there are not only nutritional disturbances in the nuclear region but, in addition, disturbances in the sympathetic pathways accounting for the rhythmic spastic phenomena. Axenfeld and Schürenberg pointed out that since accommodation innervation is always bilateral, and in these cases it is purely unilateral, a congenital anomaly of the connecting fibers of the nuclei of both sides of the brain must be assumed before the site of the lesion can be considered nuclear. Other writers have also called attention to the fact that fibers from the posterior end of each oculomotor nucleus cross over to the other side and that, therefore, a nuclear lesion on one side should, in addition to paralysis of the muscles supplied by the third nerve on one side, show some impairment of the muscles of the other eye. A lesion located peripheral to the nucleus and central to the point of emergence of the trunk of the oculomotor nerve from the brain is thought to explain the purely unilateral involvement better than the other theory.

---

11. Fromaget: Arch. d'opht., 1906, no. 16, p. 230.
12. Aurand and Breuil: Arch. d'opht. **26**:74 (Feb.) 1906.
13. Mosso: Ann. di ottal. **42**:231, 1913.

Bielschowsky, in an effort to account for all the phenomena, assumed that in these cases there is an anomalous blood supply to the oculomotor nucleus, and he further doubted that fibers from one third nucelus cross over to the opposite side. He expressed the belief that there is a destructive lesion in the nucleus of the third nerve with sparing of the ganglion cells concerned with the innervation of the muscles taking part in the cyclic changes. He explained the lack of response to volition and physiologic stimuli on the basis of a supranuclear lesion in the vicinity of the nucleus. He thought that there might be an involvement of the nerve trunk in some cases. He accounted for the cyclic spastic features by vasomotor stimulation resulting in increased blood supply to the foregoing regions.

Behr [14] stated that the ganglion cells belonging to the muscles participating in the automatic movements are grouped closely together in the anterior portion of the oculomotor nucleus while the cells belonging to the permanently paralyzed muscles are located in the middle and posterior portions of the main nucleus. Bernheimer proved that each one of these divisions has its own blood supply, the anterior pole through branches from the carotid and the posterior pole through branches coming from the basilar artery. Since most cases are congenital, one can assume, in the presence of the retained irritability of the anterior nuclei, a congenital aplasia of the corticonuclear pathways and the reflex contact neurons. By some difference in the blood supply, the cells of the anterior division of the nucleus are spared from complete degeneration while the posterior ones degenerate. The sparing of part of the nucleus and the centripetal paths offers a possibility that through the normal blood supply there is a cumulative storage of energy in the ganglion cells which discharges itself rhythmically into the muscular periphery.

COMMENT

Just what rôle the congenital syphilitic infection plays in the case reported is hard to say, but it seems not unlikely that it may be the underlying etiologic factor, particularly if one can accept the patient's statement that the periodic phenomena of the lid, which he refers to as openings of the lids, began after his first course of antisyphilitic treatment.

55 East Washington Street.

14. Behr, C., in Graefe-Saemisch: Handbuch der gesamten Augenheilkunde, Leipzig, Wilhelm Engelmann, 1924, vol. 2, p. 115.

SIZE OF OBJECTS IN RELATION TO THEIR VISIBILITY AND TO THE RATING OF VISION *

C. E. FERREE, PH.D.
AND
GERTRUDE RAND, PH.D.
BALTIMORE

The three most important physical factors in the visibility of objects are size of visual angle of the detail to be discriminated, difference in coefficient of reflection between object and background and intensity of illumination. These factors are, of course, interacting in their effect on the eye. That is, changes in size will produce different changes in visibility with different relations of object to background and at different intensities of illumination. A visual angle of 1 minute, for example, represents a low visibility at a low intensity of illumination or with a small difference in coefficient of reflection between object and background, and a comparatively high visibility at a high illumination or with a large difference in coefficient of reflection between object and background. The visibilities for two values of visual angle may sustain one ratio at one intensity of illumination and relation to background and a different ratio at another intensity of illumination and relation to background. In short, a scale showing the relation of size of object to visibility determined for one intensity of illumination and relation to background cannot be expected to hold for other intensities of illumination and relations to background. It is not our purpose in this paper, however, to discuss in any great detail the intricacies of these interactions.

The influence of size and relation to background on the visibility of objects is in the main perhaps obvious to all, i. e., one sees objects because of their size and their difference from the background. Just what part is played by intensity of illumination is, however, not so obvious. There seem to be two possibilities as to the influence of the intensity factor: (*1*) an effect on the visual or sensation difference from the background and (*2*) an effect on the visual or apparent size. The first effect has been treated by us in former papers.[1] The points related to this effect may be summarized as follows: (1) With a given difference in coefficient

* Submitted for publication, Feb. 4, 1930.

* From the Research Laboratory of Physiological Optics, Wilmer Ophthalmological Institute, Johns Hopkins Medical School.

1. Ferree, C. E., and Rand, G.: Intensity of Light and Speed of Vision Studied with Special Reference to Industrial Situations, Tr. Illum. Engin. Soc. **23**:507, 1928; Lighting and the Hygiene of the Eye, Arch. Ophth. **2**:1 (July) 1929.

of reflection the visual or sensation difference is greater in case of white objects on black or light objects on dark backgrounds than it is in case of black objects on white or dark objects on light backgrounds; (2) the sensation difference increases rapidly with increase of intensity of illumination;[2] (3) the increase is more rapid for white objects on black or light objects on dark backgrounds than for black on white or dark objects on light backgrounds.

The second effect will be made the subject of a later paper. With reference to it, however, a few words may be said tentatively here. 1. There is an irradiation or spreading of the excitation aroused by the image on the retina, the amount of which is affected by the intensity or density of the light in the image. The influence of this is to increase the effective size of a detail in black on white or in dark on a light background and to decrease the effective size of a detail in white on black or in light on a dark background. 2. An increase in the size of a luminous or illuminated area gives an effect of increase of intensity, but not in proportion to the increase in size. This action may be reciprocal, i. e., an increase of intensity may give to some extent the effect of an increase of size. This effect, however, so far as we know, has not as yet been shown experimentally.

A great deal of space could be taken in showing the effect of intensity of illumination and relation to background on power to see when the size of the object or visual angle is taken as a measure. That is, however, not primarily our purpose in this study. We wish rather to consider the visibility of objects when intensity of illumination and relation to background are held constant.

Obviously such considerations as are to be discussed in this paper have no direct or necessary bearing on the use of test objects graded as to visual angle in the diagnosing and correcting of errors of refraction. The objective in that procedure is to find the correction that enables the discrimination of the smallest detail. The exact rating of the test object as to comparative visibilities is clearly of little consequence in the attainment of this objective. The rating by visual angle is sufficient to maintain the serial order of visibilities needed, provided that the other factors influencing visibility are held constant. The considerations to be discussed in this paper become important, therefore, only when

---

2. There are several factors involved in this effect: (*a*) size of pupil; (*b*) difference in amount of light reflected from object and background with a given difference in coefficient of reflection; (*c*) the selectiveness of the sensitivity of the eye at different points in the intensity scale and the variations of this with state and stage of adaptation; (*d*) relation of object to background, light on dark or dark on light, etc. The net result of all the factors is that the visual or sensation difference of the object from its background increases rapidly with increase of intensity of illumination.

questions of rating visibility and the power to see or vision are involved. Such questions are raised when a numerical comparison is wanted of the merits of the various conditions and situations involving the use of the eye and of the powers of vision of different persons and of a given person at different times. As examples of cases of the former class may be mentioned the comparative ratings of lighting situations and installations; the selection of objects and the arrangement of objects and background in various industrial tasks; the formulation of specifications for the printed page, and the choice of combinations of object and background for certain types of test charts, for signs, signals, license plates, tags, reading scales of instruments and other designations requiring a high visibility; and as examples of cases of the latter class, ratings as to vocational fitness when some comparison of visual powers is wanted, the various cases in which there is need to evaluate damages to vision from the legal or other points of view, impairment to vision due to abnormalities of various kinds and changes in these abnormalities, etc. In connection with the correction of defects in refraction, the considerations in question are of importance primarily in evaluating the benefits that have been obtained by the corrections made and their rather wide variation per unit value of scale in the different parts of the scales that have been formulated by Snellen and his contemporaries.

In approaching an investigation or study of the effect of any of these factors, one is confronted with the question of a measure of visibility. In conventional acuity testing, size of object or visual angle has itself been taken as the measure of visibility, and the power to see has been rated in simple inverse relationship to the size of the smallest detail that can be discriminated. That is, apparently a detail subtending twice the visual angle of another detail is assumed to have twice its visibility; three times its visual angle, three times its visibility, etc. The visual angle and the visibility scale are assumed to be numerically equivalent; and power to see, or vision as it is usually called, which probably should be considered to sustain a simple inverse relation to visibility, is also considered to sustain an inverse relation to visual angle. In this connection it may be pointed out too that eyes have frequently been rated as having the same vision or power to see when the tests were conducted at different intensities of illumination and with different relations of object to background.

Such assumptions with reference to visibility and to vision are justified, of course, only in case it is held that visual angle and visibility sustain to each other a 1 : 1 relation. Visual angle is an important factor in visibility, but it is scarcely necessary to say at this stage in the analytic study of the visual function that this equivalence of visual angle and visibility does not exist. As already indicated, visual angle does not even sustain a fixed relation to visibility unless the other factors affect-

ing visibility are held constant. Even as a matter of record, therefore, any attempt at a specification of vision in terms of visual angle alone presupposes constancy of conditions with reference to the other factors. Without this constancy the specification is not adequate for the purpose of securing reproducibility of result. A scale expressing the correct numerical relation between change in visual angle and change in visibility cannot be given at the present time and perhaps can never be given with a satisfactory degree of accuracy. Comparisons can be made, however, of the ratings based on visual angle with those obtained from testing other important aspects of visibility.

With reference to the comparative effect of the three important factors: size, relation to background and intensity of illumination on the visibility of objects, we have found that speed of seeing, taken as the reciprocal of the shortest time in which the discrimination of the detail in question can be made, is a sensitive measure of visibility. The direct measure in any instance would have to be, of course, in terms of just noticeable steps or differences in visibility. The judgment required for this measure would, however, be difficult to make and the procedure in determining the steps of difference so time-consuming as to be somewhat infeasible for the many conditions or situations in which a factor may be operative. The correctness of speed as a measure, if visibility is conceived as that obtained with the optimum time of exposure, is vitiated to some extent as yet unknown by the selective action of the factors in question on the rate of rise of sensation. Considered in relation to its practical bearing, however, speed is an important aspect of seeing and of visibility. Also in case of the present study it has the advantage of being completely outside the group the effects of which are to be compared, i. e., within the group the effect of any two could be compared, but the effect of the third could not enter into the comparison.

Thus far there have been no attempts to check the rating of visibilities in terms of visual angle against any scale of values experimentally determined. It has been the purpose in the present study to provide experimental data showing the relation of visual angle to speed taken as a measure of visibility for a wide range of intensity of illumination and for different relations of object to background, and to compare the ratings of visibility and vision derived from these data with the conventional ratings in terms of visual angle.

METHOD

It was our wish to conduct the tests for the effect of changes of size of object on speed of vision with a good control of all the illumination factors and one that would be uniform from intensity to intensity. Also when needed we wished

to be able to vary the general illumination of the room in finely graded steps. These conditions of control for the wide range of intensities required could best be obtained from daylight illumination. The tests were conducted, therefore, in a daylighted optics room especially fitted up for the purpose. This room was 16 ft. long, 13 ft. wide and 12 ft. high. The walls were painted a mat white and the floor a light gray. The room was provided with two windows on one side, 3 by 6.5 ft., and a skylight 12 by 9 ft. Beneath the skylight was a light-well 8 ft. deep at one end and 5 ft. at the other. The walls of this light-well were painted mat white. Beneath the light-well were swung two diffusion sashes of ground glass, each 12 by 4.5 ft. All of the light entering the room from the light-well passed through these sashes. To provide for the ventilation of the room the sashes were dropped 11 inches below the opening of the light-well.

In order to provide for the control and variation of the amount of daylight entering the light-well, two sets of curtains were installed directly beneath the skylight, one set consisting of four overlapping light-proof curtains to provide for the gross changes, the other of three thin white curtains to give the finer changes often needed in maintaining constancy of illumination. Beneath the diffusion sashes were also installed three sets of curtains, one a broad light-proof curtain covering the entire ceiling of the room, the edges of which were enclosed to a depth of several inches in a light-tight boxing, and two sets of thin white curtains, one running lengthwise of the room and the other crosswise. These two systems of curtains could be used singly or in combination as might be needed. By means of them minute changes of intensity could be made and the room was illuminated at all intensities by a soft, evenly distributed, well diffused light which gave no glare on the working surface or anywhere in the field of view. The windows were also provided with light-proof curtains for the gross and thin white curtains for the fine changes in illumination. Each of the light-proof curtains, overhead and window, was painted mat white on the inside.

The experiments were conducted at intensities of illumination ranging from 1.25 to 100 foot-candles at the test surface. At each intensity the vertical and horizontal components of illumination were made equal. This was done in order that the size of pupil should not be influenced by an intensity of light higher than that coming from the test surface. In making the equalization, two duplicate test plates for the Macbeth illuminometer were mounted at right angles to each other on a tripod stand. This stand was placed so that the vertical plate was inserted in the position of the test surface and gave the measure of the horizontal component of illumination, while the second plate, mounted at the level of its lower edge, furnished the measure of the vertical component. Supplementary tests showed that if this control of the two components of illumination was not exercised, a difference in result was obtained. It was deemed best, therefore, to control both components, the purpose being to conduct the experiments under conditions as nearly as possible free from the influence of all variables but the one under investigation. The additional light used to increase the horizontal component could be obtained in most cases from the two curtained windows. In the case in which enough could not be had from the windows, additional light was obtained from a Macbeth artificial daylight unit. Frequent measurements were made of both the horizontal and the vertical components of illumination during each series of exposures contributing to one determination of speed, and great care was taken that the determinations were always made at the intensity specified.

The tests were made with the rotary tachistoscope described in former papers.[3] In order to provide for the wide range of lengths of exposure that was needed, a series of special gears was made designed to give low, medium and high speeds of rotation of the disk. The broken circle, the international test object, mounted at the center of a rotatable, graduated dial was used as test object. Sizes were chosen such that the opening in the circles, the detail to be discriminated, subtended visual angles of 1, 2, 3, 4.2 and 5.2 min. of arc, and backgrounds having coefficients of reflection of 78, 29, 21, 16 and 4 per cent. In making the observation all that was required of the observer was to indicate the direction in which the opening pointed. The judgment was thus reduced to simple terms, and an objective check was had on its correctness. Eight positions of the opening of the circle, presented in haphazard order, were used—up, down, right, left and the four 45 degrees positions—and a correct judgment was required in five of the eight positions in the determination of the exposure time needed for the discrimination of the test object. The breadth of the opening was measured in each case on a micrometer comparator and the visual angle computed. The distance from the eye was 2.5 meters. On the front surface of the exposure disks in line with the observer's eye and the test object was placed a fixation cross in order that the exposure might begin with the eye in approximate adjustment for the test object. Constancy of position of the eye was secured by biting a mouthboard in which the impression of the teeth had been previously made and hardened in wax. The preexposure and surrounding field were made in each case of the same brightness as the test surface. The eye was allowed to adapt to each intensity of light through a thirty minute practice series provided with proper rest periods. Great care was taken to keep the eye in an unchanging state of adaptation and to prevent fatigue. In particular, the fatigued eye becomes slow and erratic. Not only do adequate rest periods have to be provided during the course of the experiment, but extreme care has to be taken not to overtax the eyes during the days, weeks or months, as the case may be, in which the experiments are being conducted. Unless a rigorous control is had of the factors of adaptation and fatigue, accuracy and precision of result cannot be hoped for in any of the more delicate tests of acuity.

Because of the extended scope of the study and the need for comparison of the results on every point, it has been possible to conduct the entire series of experiments on only one observer, R. The more important points, however, have been verified on four additional observers. Further, comparisons have been made of observer R's speed with that of other observers, trained and untrained, under the same test conditions. These comparisons have shown that this observer ranks approximately average in a group of trained observers selected with special reference to good refraction, muscle balance, etc., and is in the upper quartile when compared with a group of untrained, unselected observers.

Only the right eye was used in making the tests. The left eye was open but screened from the test object by a white card attached to the mouthboard. Preliminary studies showed that this observer's speed was nearly the same with the

3. Ferree, C. E., and Rand, G.: The Inertia of the Eye for Clear Seeing at Different Distances, Am. Ophth. Soc. Tr. **16**:142, 1918; The Inertia of the Eye for Clear Seeing at Different Distances: A Study of Ocular Functions with Special Reference to Aviation, Am. J. Ophth. **1**:764, 1918; The Effect of Variations in Intensity of Illumination on Functions of Importance to the Working Eye, Tr. Illum. Engin. Soc. **15**:769, 1920.

right eye as with both eyes. The monocular condition was chosen, therefore, in order that a comparison might be made of the speed of vision with the natural and with an artificial pupil. This comparison could not have been made with binocular vision.

RESULTS

As was stated earlier in the paper, the determinations of speed were made for five sizes of opening of the broken circle or detail to be discriminated (1, 2, 3, 4.2 and 5.2 min. of arc) at illuminations ranging from 1.25 to 100 foot-candles and for backgrounds having different coefficients of reflection (78, 29, 21, 16 and 4 per cent). The study was made under the auspices of the National Research Council's Committee on Industrial Lighting with special reference to industrial situations. The visual angles chosen have been considered representative of sizes of work for which change of intensity of illumination and of relation of object to background have an important ocular effect; the coefficients of reflection are, respectively, those of a white surface of good reflecting power, polished steel and brass, unpolished steel and brass, iron, and a black surface of low reflecting power. For the somewhat special purpose of the present paper, it is obvious that values of visual angle less than 1 minute and between 1 and 2 minutes should have been included. That is, it is within this range of sizes that ratings of visibility in terms of visual angle show their greatest discrepancies with measured values of visibility. Also for the purposes of the present paper a greater number of backgrounds should have been used, distributed more uniformly in the scale of reflecting powers.

Size as a Factor in Speed of Vision.—The results pertaining to this factor are given in table 1 and are shown in charts 1 to 8. Charts 1 to 6 show the effect for different intensities of illumination with a given relation of object to background; in chart 7, for different relations of object to background at a given intensity of illumination. In the results given in the tables and charts, speed of seeing is taken as the measure of the visibility of the object under the conditions as to intensity of illumination and relation of object to background specified. As in former studies, speed of seeing is expressed as the reciprocal of the smallest interval of time in which the object can be discriminated, i. e., as the reciprocal of the time threshold of discrimination. The time threshold seems to be a sensitive, important and feasible measure of the relation of changes in size, difference from background and intensity of illumination to changes in visibility, as was stated in the introduction.

In chart 1 the effect of change of size of object is shown for the black test object on white (coefficients of reflection 3 and 78 per cent) at intensities of illumination ranging from 1.25 to 100 foot-candles; in charts 2 to 4, for the black test object on gray backgrounds with coefficients of reflection, respectively, of 29, 21 and 16 per cent (coefficient of

reflection of test object 4 per cent); in charts 5 and 6, for the white test object on a black background (coefficients of reflection 78 and 4 per cent) and on a gray background having a coefficient of reflection of 21 per cent. In these charts visual angle is plotted on the horizontal coordinate and speed on the vertical coordinate. For the convenience of the reader, on

TABLE 1.—*Speeds Obtained with Approximately Equal Differences in Brightness, Expressed in Millilamberts Between Object and Background When These Differences Were Obtained by the Appropriate Combination of Low Coefficient of Reflection and High Illumination and High Coefficient of Reflection and Low Illumination*

Coefficient of Reflection of Background (per Cent)	Illumination (Ft.-c.)	Difference in Brightness Between Object and Background (Mi.)*	Speed for Visual Angles				
			1 Minute	2 Minutes	3 Minutes	4.2 Minutes	5.2 Minutes
78	15.0	12.10	28.6	161.3	204.1	263.2	319.5
29	50.0	13.45	30.8	66.7	112.7	148.2	181.8
21	75.0	13.72	27.3	59.4	97.6	127.0	153.9
16	100.0	12.91	22.2	54.1	87.0	117.6	135.6
78	10.0	8.07	22.6	133.3	186.9	253.2	307.7
29	30.0	8.07	22.9	56.2	100.0	133.3	166.7
21	50.0	9.15	22.0	51.3	87.0	112.7	137.9
78	7.5	6.03	19.7	109.9	166.7	235.0	294.1
29	20.0	5.38	17.4	46.3	90.9	125.8	156.9
21	30.0	5.49	16.1	41.7	74.1	100.0	125.0
78	5.0	4.00	16.5	82.6	142.9	200.0	250.0
29	15.0	4.04	14.5	40.7	83.3	116.3	145.5
21	20.0	3.66	12.3	34.8	65.4	92.0	114.3
16	30.0	3.87	11.0	32.2	59.9	83.3	100.0
78	2.5	2.02	11.3	51.3	96.2	146.0	185.2
29	7.5	2.02	8.9	31.5	65.4	85.1	114.3
21	10.0	1.83	8.1	25.1	51.0	75.5	94.2
16	15.0	1.94	7.3	22.1	42.8	67.8	83.3
29	5.0	1.35	5.8	26.5	53.5	71.9	97.6
21	7.5	1.38	6.3	22.0	45.9	67.8	87.0
16	10.0	1.29	5.9	18.6	35.7	58.8	74.1
78	1.25	1.01	6.7	35.3	62.5	95.2	125.0
21	5.0	0.91	...	18.2	38.5	55.3	75.5
16	7.5	0.97	...	15.5	30.3	52.6	64.9
29	2.5	0.68	...	19.3	40.3	54.1	72.7
16	5.0	0.65	...	11.8	24.5	42.4	53.5
29	1.25	0.33	...	11.9	26.9	42.9	57.8
16	2.5	0.32	...	8.6	17.9	28.1	36.0

* Millilamberts = foot-candles × 1.076 × coefficient of reflection.

the right of the chart is noted also the time in seconds corresponding to various points on the scale of reciprocals. Since time values do not space equally on this scale, intermediate points cannot, of course, be obtained from the chart by direct interpolation. Also at the right of the chart is given the difference in brightness between object and background expressed in millilamberts, and the diameter of the pupil in millimeters for each of the intensities of light used in the experimental determination. The size of pupil should, we believe, be specified in the presentation of data of this kind. Two reasons may be assigned for

this: (1) It exerts an important influence on clearness of seeing; (2) it is influenced by other factors than intensity of light as ordinarily specified, namely, the area of the illuminated surface, high brilliancies in the field of view and other components of light besides the one coming from the surface directly viewed. In short, change in size of pupil is a composite reaction to the whole field of view and not alone to the object looked at. In the present series of experiments, for example, different results were obtained both for size of pupil and for speed of vision when the horizontal and vertical components of illumination were equalized and when they were not.

With reference to charts 1 to 6 the following points may be noted:

1. Large increases of speed are produced at each intensity of illumination by increasing the size of the object. For the ranges of size of object, intensity of illumination and difference in coefficient of reflection between object and background used, we have found this factor to exert a greater effect in increasing speed of vision than increase of intensity of

TABLE 2.—*Range of Ratios of Speed*

Condition of Work	Range of Illumination (Ft.-c.)	Range of Visual Angle (Minutes)	Range of Ratio of Highest to Lowest Speed Produced by Change of Visual Angle for the Illuminations Tested
Black on white.....78%	1.25 to 100	1 to 5	7 to 19
Black on gray.....29%	5.0 to 100	1 to 5	5 to 19
Black on gray.....21%	7.5 to 100	1 to 5	6 to 14
Black on gray.....10%	10.0 to 100	1 to 5	6 to 13
White on black.....4%	1.25 to 100	1 to 3	6 to 21
White on gray.....21%	1.25 to 100	1 to 3	7 to 14

light or increase in difference between object and background. For example, the greatest ratio of increase of speed produced by increase of size of object was 19; by increase of intensity of illumination it was 9, and by increase of difference between object and background it was 7. The comparison of the weight of the three factors is made for the following variations of each: 1 to 5.2 minute range of visual angle; 1.25 to 100-foot-candles, range of intensity of illumination, and 12 to 75 per cent range of difference in coefficient of reflection between object and background. Had the ranges included smaller differences between object and background, the ranking of the two latter factors as to importance in speed of vision would probably not have been in the order given.

The range of ratios of speed obtained for the visual angles used at the different intensities of illumination and for the various conditions of work is given in table 2.

The following reasons may be offered for the effect of size of object on speed of vision: 1. A less clear image is required for the discrimination of a large than of a small object; therefore less time is required for the adjustment of the focus. 2. The sensory effect develops more

rapidly for a large than for a small object. 3. Less time is required for making the judgment.

2. For the range of sizes tested, there is in general a tendency for a linear relationship to exist between size of object and the speed with which it is discriminated. That is, for a given intensity and a given relation of object to background the increment of speed corresponding to a unit increment of visual angle is, for the greater part of the results, approximately constant. The increment of speed varies, however, for different intensities of light and different relations of object to background. The point needs to be stressed, moreover, that the increment of speed per unit increment of visual angle is not for any intensity of illumination and relation of object to background even roughly proportional to the increase in visual angle, in which case the relationship between speed and visual angle would be classed as curvilinear, a type of relationship found, for example, between speed and intensity of light. In this connection it may be noted too that the conventional rating of visibilities in terms of visual angle assumes not only that the increase in visibility is proportional to the increase in visual angle but that the ratios of increase in the two scales are equal from point to point. At the lower intensities the linear relationship holds throughout the entire range of sizes of object tested for all relations of object to background, except for white on gray. For the higher intensities a more rapid increase in speed frequently occurs between some two sizes of visual angle than the remaining sizes, the location of the more rapid increase varying with the relation of object to background. Variations of this type cause a change in the slope of the curves given in the charts. The most pronounced change occurs for white on black between 1 and 2 minutes at the higher intensities.

A more detailed inspection of charts 1 to 6 brings out the following additional data: 1. In case of the black test object on white (chart 1), there is an approximately constant increment of speed per unit increment of visual angle between 1 and 5 min.[4] for 1.25 and 2.5 foot-candles, and between 2 and 5 minutes from 5 to 100 foot-candles. Between 1 and 2 minutes for the latter range of intensities there is a much greater increment of speed than between 2 and 3, 3 and 4 and 4 and 5 minutes. Table 3 gives typical examples of this.

2. In case of the black test object on the gray having a coefficient of reflection of 29 per cent (chart 2), the curves deviate most from linearity. There is an approximately equal increment of speed per unit

4. As stated earlier in the paper, the test objects used subtended visual angles of 1, 2, 3, 4.2 and 5.2 min. For the foregoing comparisons between size of visual angle and speed of discrimination, the speeds for 4 and 5 min. were determined by interpolation.

increment of visual angle at 1.25 foot-candles; from 2.5 to 10 foot-candles there is a greater increment of speed between 2 and 3 minute visual angles, and a smaller increment between 3 and 4 minutes than between 1 and 2 and 4 and 5 minutes; and from 15 to 100 foot-candles there is an approximately equal increment between 1 and 2, 3 and 4 and

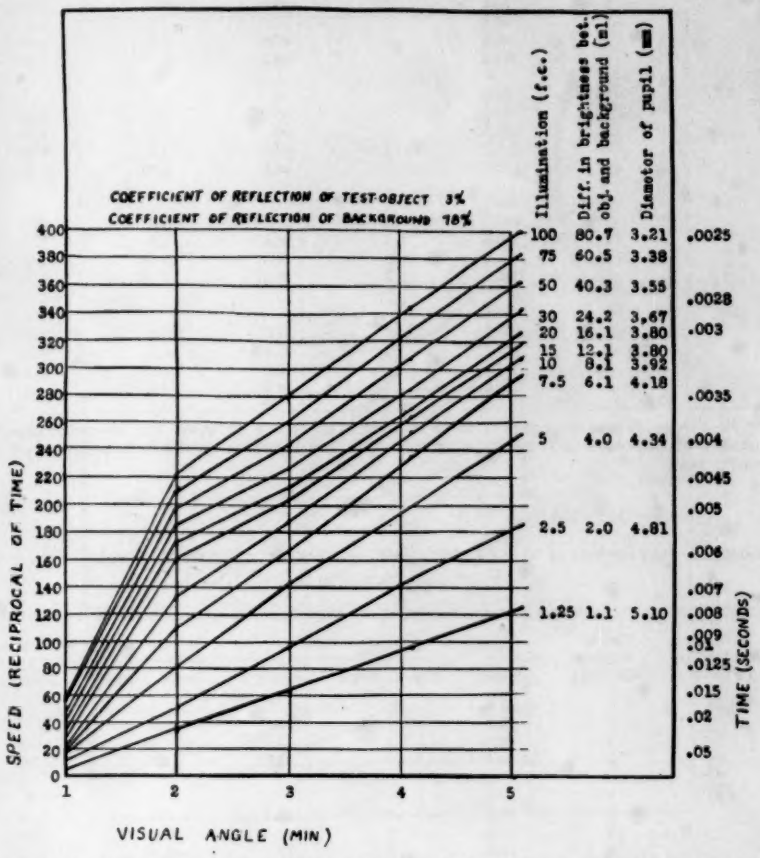


Chart 1.—The effect of increase of visual angle on speed of vision for a black test object on a white background, coefficients of reflection, 3 and 78 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal of time) plotted against minutes of visual angle.

4 and 5 minute visual angle, and a greater increment between 2 and 3. Typical examples of this are shown in table 4.

3. In case of the black test object on the gray having a coefficient of reflection of 21 per cent (chart 3), there is an approximately equal increment of speed per unit increment of visual angle from 1.25 to 5 foot-candles; from 7.5 to 30 foot-candles it is approximately equal

TABLE 3.—*Increment of Speed per Unit Increment of Visual Angle; Black on White* *

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
1.25	1	6.7				
	2	35.3	1	28.6	2.0	5.27
	3	62.5	1	27.2	1.5	1.77
	4	90.0	1	27.5	1.33	1.44
	5	119.3	1	29.3	1.25	1.33
2.5	1	11.3				
	2	51.3	1	40.0	2.0	4.55
	3	96.2	1	44.9	1.5	1.87
	4	137.2	1	41.0	1.33	1.43
	5	177.5	1	40.3	1.25	1.29
7.5	1	19.7				
	2	109.9	1	90.2	2.0	5.58
	3	166.7	1	56.8	1.5	1.52
	4	224.0	1	57.3	1.33	1.34
	5	280.5	1	56.5	1.25	1.25
75.0	1	54.4				
	2	208.3	1	153.9	2.0	3.83
	3	259.7	1	51.4	1.5	1.25
	4	316.0	1	56.3	1.33	1.22
	5	370.8	1	54.8	1.25	1.17

* In this table and in tables 4 to 10 selections are made to show the approximation to constancy of increment and the type of deviation which occurs at different portions of the intensity scale.

TABLE 4.—*Increment of Speed per Unit Increment of Visual Angle; Black on Gray, Twenty-Nine Per Cent*

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
1.25	2	11.9				
	3	26.9	1	15.0	1.5	2.26
	4	40.2	1	13.3	1.33	1.50
	5	54.8	1	14.6	1.25	1.36
5.0	1	5.8				
	2	26.5	1	20.7	2.0	4.57
	3	53.5	1	27.0	1.5	2.08
	4	68.8	1	15.3	1.33	1.28
	5	92.0	1	23.2	1.25	1.34
15.0	1	14.5				
	2	40.7	1	26.2	2.0	2.81
	3	83.3	1	42.6	1.5	2.05
	4	110.8	1	27.5	1.33	1.33
	5	139.6	1	28.8	1.25	1.26
75.0	1	38.1				
	2	74.1	1	35.9	2.0	1.94
	3	123.1	1	49.1	1.5	1.66
	4	156.8	1	33.7	1.33	1.27
	5	192.8	1	36.0	1.25	1.23

between 1 and 2, 3 and 4 and 4 and 5 minutes of visual angle and greater between 2 and 3 minutes; and from 50 to 100 foot-candles it is approximately equal between 3 and 4 and between 4 and 5 minutes of visual angle, greatest between 2 and 3 and next greatest between 1 and 2. These variations in size of increment of speed are not as great, as is seen from the shape of the curves in chart 3 and from the examples given in table 5.

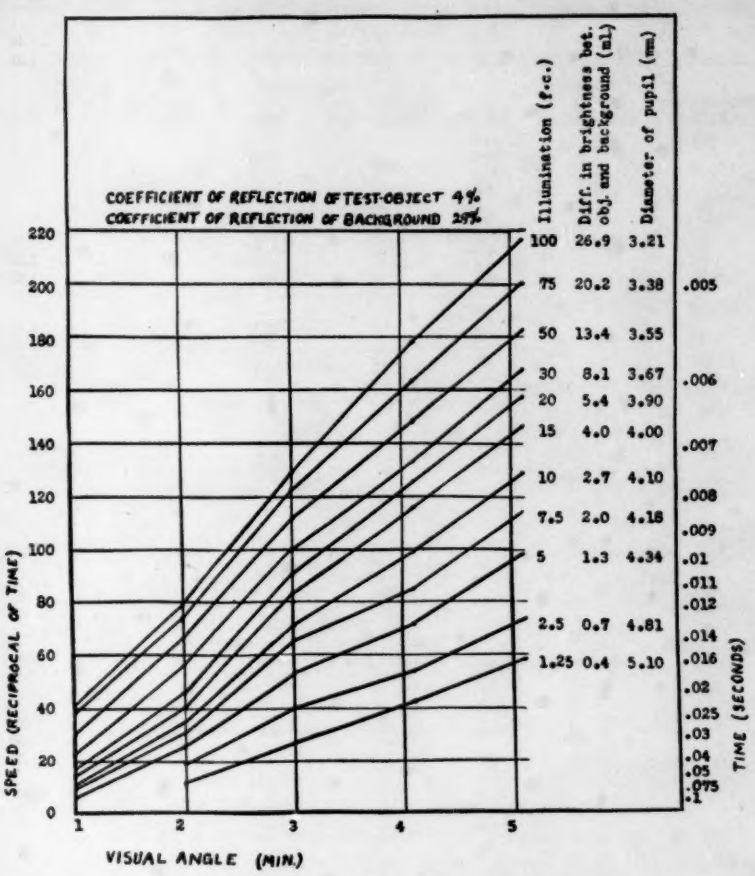

COEFFICIENT OF REFLECTION OF TEST-OBJECT 4%
COEFFICIENT OF REFLECTION OF BACKGROUND 21%
Illumination (f.c.)
Diff. in brightness bet. obj. and background (ml.)
Diameter of pupil (mm)
100 26.9 3.21
75 20.2 3.38
50 13.4 3.55
30 8.1 3.67
20 5.4 3.90
15 4.0 4.00
10 2.7 4.10
7.5 2.0 4.18
5 1.3 4.34
2.5 0.7 4.81
1.25 0.4 5.10
SPEED (RECIPROCAL OF TIME)
0 20 40 60 80 100 120 140 160 180 200 220
VISUAL ANGLE (MIN.)
1 2 3 4 5
TIME (SECONDS)
.005 .006 .007 .008 .009 .01 .011 .012 .014 .016 .02 .025 .03 .04 .05 .075 .1

Chart 2.—Effect of increase of visual angle on speed of vision for a black test object on a gray background, coefficients of reflection, 4 and 21 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal of time) plotted against minutes of visual angle.

4. In case of the black test object on the gray having a coefficient of reflection of 16 per cent (chart 4), there is an approximately equal increment from 1.25 to 10 foot-candles, and a slightly greater increment between 2 and 3 and 3 and 4 minutes of visual angle than between 1 and

2 and 4 and 5 from 15 to 20 foot-candles, and between 1 and 2 and 2 and 3 than between 3 and 4 and 4 and 5 minutes from 30 to 100 foot-candles. In this case also, the deviations from a constant value are small.

5. In case of the white test object on black (chart 5), there is a constant increment of speed per unit increment of visual angle from

TABLE 5.—*Increment of Speed per Unit Increment of Visual Angle; Black on Gray, Twenty-One Per Cent*

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
2.5	2	13.0				
	3	26.2	1	13.2	1.5	2.86
	4	37.2	1	11.0	1.33	2.08
	5	50.8	1	13.6	1.25	1.39
10	1	8.1				
	2	25.1	1	17.0	2.0	3.10
	3	51.0	1	25.9	1.5	2.03
	4	71.6	1	20.6	1.33	1.40
	5	90.6	1	19.0	1.25	1.26
20	1	12.3				
	2	34.8	1	22.5	2.0	2.83
	3	65.4	1	30.6	1.5	1.88
	4	87.6	1	22.2	1.33	1.34
	5	110.0	1	22.4	1.25	1.26
75	1	27.3				
	2	59.4	1	32.1	2.0	2.18
	3	97.6	1	38.5	1.5	1.64
	4	122.0	1	24.4	1.33	1.25
	5	148.0	1	26.2	1.25	1.21

TABLE 6.—*Increment of Speed per Unit Increment of Visual Angle; Black on Gray, Sixteen Per Cent*

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
2.5	2	8.6				
	3	17.9	1	9.3	1.50	2.08
	4	26.5	1	8.6	1.33	1.48
	5	34.4	1	7.9	1.25	1.30
15	1	7.3				
	2	22.1	1	14.8	2.0	3.03
	3	42.8	1	20.7	1.50	1.94
	4	63.8	1	21.0	1.33	1.49
	5	80.3	1	16.5	1.25	1.26
50	1	15.6				
	2	42.4	1	26.8	2.0	2.72
	3	70.8	1	28.4	1.50	1.67
	4	90.2	1	19.4	1.33	1.27
	5	109.0	1	18.8	1.25	1.21

1.25 to 10 foot-candles, and a greater increment between 1 and 2 than between 2 and 3 minutes of visual angle from 15 to 100 foot-candles.

6. In case of the white test object on the gray having a coefficient of reflection of 21 per cent (chart 6), there is a constant increment of speed per unit increment of visual angle from 10 to 20 foot-candles; below 10 foot-candles the increment between 1 and 2 minutes of visual

angle is slightly less than between 2 and 3, and above 20 foot-candles it is slightly greater.

3. In general, the speed for the white test object on black is greater than for the black test object on white, and for the white test object on gray than for the black on gray; also a greater increase in speed is produced by increasing the size of the test object for the former than for the latter relation of object to background. This is shown in table 9.

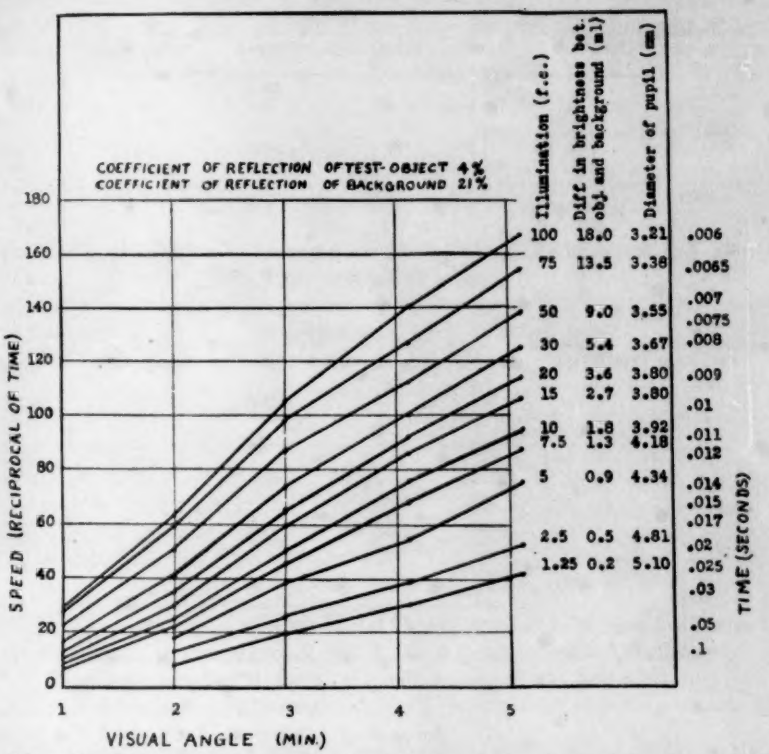


Chart 3.—Effect of increase of visual angle on speed of vision for a black test object on a gray background, coefficients of reflection, 4 and 16 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal of time) plotted against minutes of visual angle.

These results would seem to point to the following practical conclusions: 1. For the speedy discrimination of small objects there is great need for high intensities of light and large differences between object and background. 2. As the size of detail to be discriminated is increased, there is less need of high intensities and large differences between object and background so far as speed of vision is concerned. 3. For all but sizes of object near the threshold of discrimination, light on dark is a more favorable relation of object to background than dark on light.

In applying these data to practical working conditions, the value of the visual angle may in any case be computed from the following formula: *tan.* ½ visual angle $=\frac{\frac{1}{2}\ S}{D}$, in which S is taken as the size or breadth of the detail to be discriminated and D is the distance of the eye

TABLE 7.—*Increment of Speed per Unit Increment of Visual Angle; White on Black*

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
2.5	1	10.2				
	2	78.4	1	68.4	2.0	7.69
	3	148.2	1	69.8	1.5	1.89
30	1	55.6				
	2	243.9	1	188.3	2.0	4.40
	3	400.0	1	156.1	1.50	1.64

TABLE 8.—*Increment of Speed per Unit Increment of Visual Angle; White on Gray, Twenty-One Per Cent*

Illumination (Ft.-c.)	Visual Angle (Minutes)	Speed	Increment of		Ratio of	
			Visual Angle	Speed	Visual Angle	Speed
2.5	1	9.0				
	2	37.3	1	28.3	2.0	4.15
	3	93.0	1	55.7	1.5	3.57
15	1	23.5				
	2	116.3	1	92.8	2.0	4.95
	3	205.3	1	89.0	1.5	1.76
50	1	36.5				
	2	169.5	1	133.0	2.0	4.64
	3	283.3	1	113.8	1.5	1.67

TABLE 9.—*Range of Ratios of Speed Obtained for the Same Ranges of Size and Intensity of Illumination for the White Test Object on Black and on Gray and for the Black Test Object on White and on Gray*

Condition of Work	Range of Illumination (Ft.-c.)	Range of Visual Angle (Minutes)	Range of Ratio of Highest to Lowest Speed Produced by Change of Visual Angle
White on black	1.25 to 100	1 to 3	6 to 21
Black on white	1.25 to 100	1 to 3	5 to 9
White on gray 21%	7.5 to 100	1 to 3	7 to 9
Black on gray 21%	7.5 to 100	1 to 3	4 to 7

from the work. Examples of size of visual angle for well known objects placed at the conventional reading distance from the eye, 33 cm. (13 in.), and at the approximate working distance, 50 cm., are given in table 10.

In the eleven charts given in chart 7 the effect of size on speed can be compared for the different relations of object to background at a given intensity of illumination for each of the eleven intensities

employed. It will be noted that increase of difference of coefficient of reflection between object and background has an effect similar to increase of intensity of illumination, i. e., (*a*) the speed is greatly increased for each of the conditions tested; (*b*) the curves become more steeply pitched as the difference in coefficient of reflection is increased, and (*c*) the deviation from linear relationship becomes greater as the difference in coefficient of reflection is increased. It will be seen from these data that much might be done to improve industrial conditions by giving due attention to the selection of the background against which the object

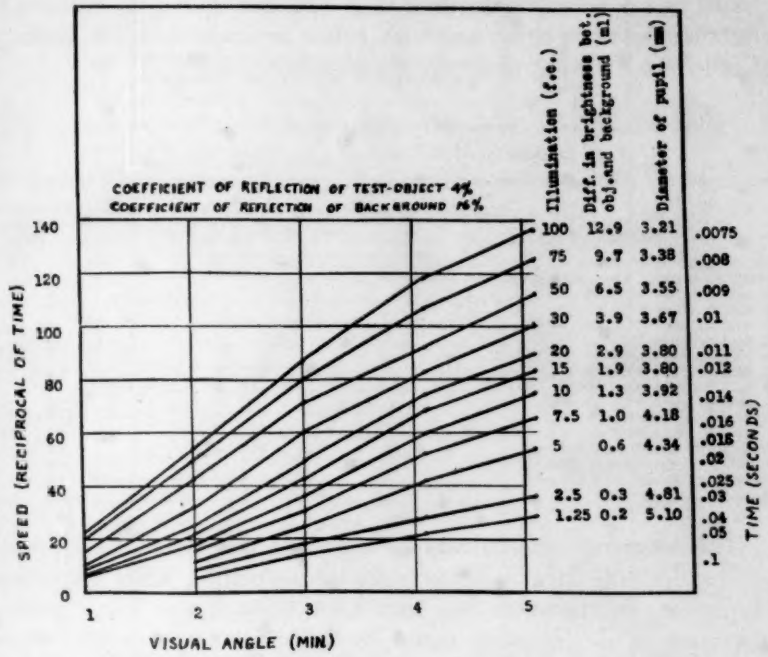


Chart 4.—Effect of increase of visual angle on speed of vision for a black test object on a black background, coefficients of reflection, 78 and 4 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal of time) plotted against minutes of visual angle.

is to be viewed. Great increase in the visibility of the object may be attained in this way as well as by an increase in the intensity of illumination.

The question might be raised in connection with these data whether equal speeds should not have been expected when equal differences in the amount of light reflected from object and background were obtained, whether the results were obtained by an appropriate combination of low coefficient of reflection of background and high illumination or the

converse, high coefficient of reflection of background and low illumination. That the same speeds were not obtained is shown in chart 8 and in table 1. In this chart and in table 1 the difference between object and background is specified in units of brightness, millilamberts. The relation between millilamberts and foot-candles is expressed in the following formula:

$$\text{Ml.} = \text{Ft. c.} \times 1.076 \times \text{Coefficient of Reflection}$$

From the data shown in these charts and in table 1 it is seen that a higher speed is attained with a high coefficient of reflection of background and a lower illumination than with the equivalent difference in brightness between object and background produced by a low coefficient of reflection of background and a high illumination.

TABLE 10.—*Visual Angle Subtended by Significant Detail in Well Known Objects at Distances of 33 and 60 Cm. from the Eye*

Object	Distance Viewed (Cm.)	Approximate Value of Visual Angle (Minutes)
Detail in 10-point type	33	3
Detail in 6-point type (fine print)	..	2
B. and S. gage wire no. 38	..	1
B. and S. gage wire no. 32	..	2
B. and S. gage wire nos. 28-29	..	3
B. and S. gage wire no. 26	..	4
B. and S. gage wire no. 24	..	5
B. and S. gage wire no. 35	50	1
B. and S. gage wire no. 27	..	2
B. and S. gage wire no. 25	..	3
B. and S. gage wire no. 23	..	4
B. and S. gage wire no. 21	..	5
Breadth of detail of 0.145 mm.	50	1
Breadth of detail of 0.290 mm.	..	2
Breadth of detail of 0.435 mm.	..	3

The following reasons may be cited for this difference in result: 1. The eye was in a different state of adaptation when the general illumination of the room was high than when it was low. State of adaptation is an important factor in the speed of the eye's reaction. 2. The size of the pupil was also different for a high than for a low illumination. The size of the pupil is affected by other components of illumination than those coming from the objects viewed.

Visibility as Rated in Terms of Visual Angle and as Measured by Speed of Vision.—In the preceding section results have been given showing in general the relation of size of object to speed of vision. In this section these results will be presented in a form that shows the relation of size of object to visibility as measured by speed of vision. The chief purpose of this form of presentation is to bring out the somewhat striking differences in the results which are obtained when visibility is rated in terms of visual angle and when it is rated in terms of the measurement of an important aspect of the visual function. The results have been treated in three ways, showing (*a*) a comparison of the rate of change

of visibility when rated in terms of visual angle and when measured by speed of vision, (*b*) selected examples of discrepancy in the ratings given by the two scales and (*c*) a direct comparison of visibilities as rated by the two scales when 1 minute is taken as the base for the visual

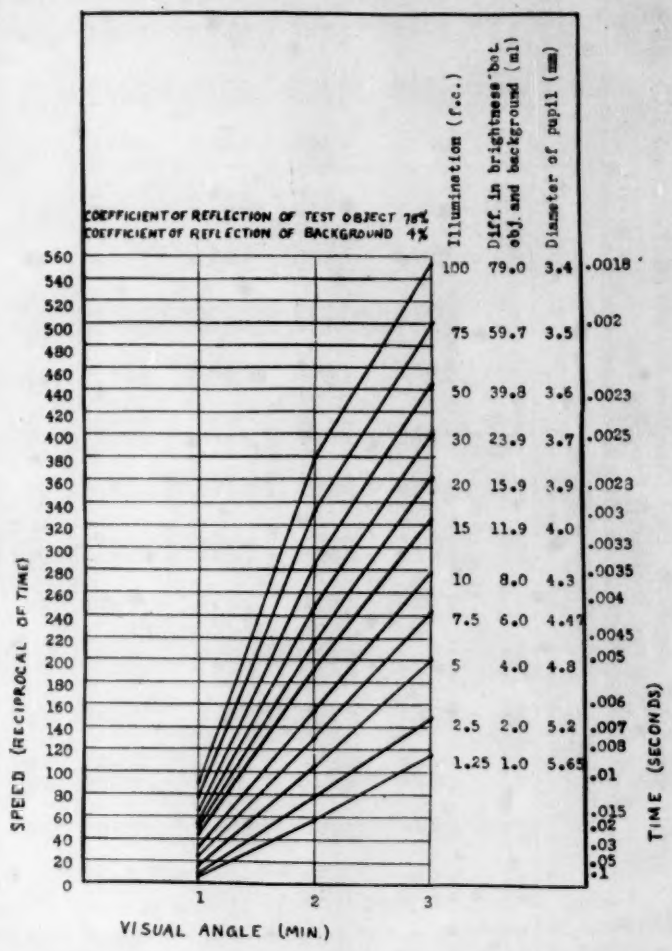


Chart 5.—Effect of increases of visual angle on speed of vision for a white test object on a black background, coefficients of reflection, 78 and 4 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal to time) plotted against minutes of visual angle.

angle scale and the speed of vision for 1 minute of visual angle as the base for the measured scale.

Table 11 has been compiled to show a comparison of the rate of change of visibility with change in size of object as measured by speed

TABLE 11.—*Rate of Change of Visibility with Change in Size of Object as Measured by Speed of Vision and as Rated in Terms of Visual Angle, for the Different Intensities of Illumination and the Different Relations of Object to Background. In This Table Are Given the Increment of Visibility and Visual Angle for Each Change in Size and the Percentage Each Increment is of the Immediately Preceding Base*

Visual Angles for Which Comparison is Made (Min. of Arc)	Increment in Visual Angle		Increment in Visibility as Measured by Speed																			
			1.25 Ft.-c.		2.5 Ft.-c.		5 Ft.-c.		7.5 Ft.-c.		10 Ft.-c.		15 Ft.-c.		20 Ft.-c.		30 Ft.-c.		50 Ft.-c.		75 Ft.-c.		100 Ft.-c.	
	Min. of Arc	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent	Visibility	Per Cent
Black on White 78%																								
1 and 2	1.0	100	28.6	427	40.0	354	66.1	401	90.2	458	110.7	490	133	464	139.1	418	14.5	361	148.5	312	153.9	283	164.2	283
2 and 3	1.0	50	27.2	77	44.9	88	60.3	73	56.8	52	53.6	40	43	27	40.4	23	42.1	23	47.9	24	51.4	25	51.8	23
3 and 4	1.0	33	27.5	44	41.0	43	47.6	33	57.3	34	55.1	30	49	24	47.7	22	48.7	21	52.9	22	56.3	22	59.0	22
4 and 5	1.0	25	29.3	33	40.3	29	49.5	26	56.5	25	52.8	22	53	21	53.5	21	54.7	20	53.5	18	54.8	18	53.5	16
Black on Gray 29%																								
1 and 2	1.0	100	....	...	....	...	20.7	357	22.6	254	23.9	213	26.2	181	28.9	166	33.3	145	35.9	117	35.9	94	38.2	94
2 and 3	1.0	50	15.0	126	21.0	109	27.0	102	33.9	108	36.3	103	42.6	105	44.6	96	43.8	78	46.0	69	49.1	66	50.3	64
3 and 4	1.0	33	13.3	49	11.4	29	15.3	20	16.6	25	22.9	32	27.5	33	29.1	32	28.0	28	29.5	26	33.7	27	41.0	32
4 and 5	1.0	25	14.6	36	17.5	34	23.2	34	26.0	32	28.7	30	28.8	26	30.6	26	31.8	25	33.2	23	36.0	23	38.2	23
Black on Gray 21%																								
1 and 2	1.0	100	....	...	....	...	....	...	15.7	249	17.0	210	20	200	22.5	183	25.6	159	29.3	133	32.1	118	35.0	122
2 and 3	1.0	50	11.7	141	18.2	102	20.3	112	23.9	109	25.9	103	29.9	100	30.6	88	32.4	78	35.7	70	38.2	64	41.6	65
3 and 4	1.0	33	8.7	44	11.0	42	14.3	37	18.3	40	20.6	40	21.5	36	22.2	34	21.6	29	21.1	24	24.4	25	29.9	28
4 and 5	1.0	25	11.3	39	13.6	37	18.7	35	19.0	30	19.0	27	21	26	22.4	26	24.6	26	24.3	22	26.2	22	26.3	20
Black on Gray 10%																								
1 and 2	1.0	100	....	...	....	...	....	...	....	...	12.7	215	14.8	203	17.0	200	21.2	193	26.8	172	29.2	144	31.9	144
2 and 3	1.0	50	8.4	142	9.3	108	12.7	108	14.8	96	17.1	92	20.7	94	24.0	94	27.7	86	28.4	67	30.5	62	32.9	61
3 and 4	1.0	33	6.3	44	8.6	48	14.9	61	18.7	62	19.1	54	21.0	49	20.3	41	18.7	31	19.4	27	22.2	28	25.8	30
4 and 5	1.0	25	6.5	32	7.9	30	12.1	31	13.3	27	16.4	30	16.5	26	17.0	24	18.0	23	18.8	21	18.8	18	19.2	17
White on Black 4%																								
1 and 2	1.0	100	52.3	951	68.2	668	89.2	518	101.7	409	121.7	379	148.3	337	166.0	330	188.4	339	218.5	332	256.1	332	292.8	329
2 and 3	1.0	50	58.5	101	69.7	89	93.6	88	117.3	93	123.9	81	132.9	69	147.4	68	156.1	64	160.7	57	166.7	50	170.8	45
White on Gray 21%																								
1 and 2	1.0	100	14.4	261	28.3	315	49.5	348	66.6	382	79.6	390	92.8	395	102.5	399	117.7	400	133.0	364	145.5	324	157.3	296
2 and 3	1.0	50	50.3	257	55.7	149	64.5	101	72.3	86	77.9	78	80.1	76	97.8	76	102.9	70	113.8	67	129.5	68	146.6	70

and as rated in terms of visual angle at the different intensities of illumination and for the different relations of object to background. In this table are given the numerical increments of speed and visual angle for each change in size and the percentage this increment is of the immediately preceding base. The principle employed in making the determination was similar to that which is used in computing the Fechner Fraction, i. e.,

$$\text{Percentage} = \frac{\text{Speed at 2 min.—Speed at 1 min.; etc.}}{\text{Speed at 1 min.}}$$

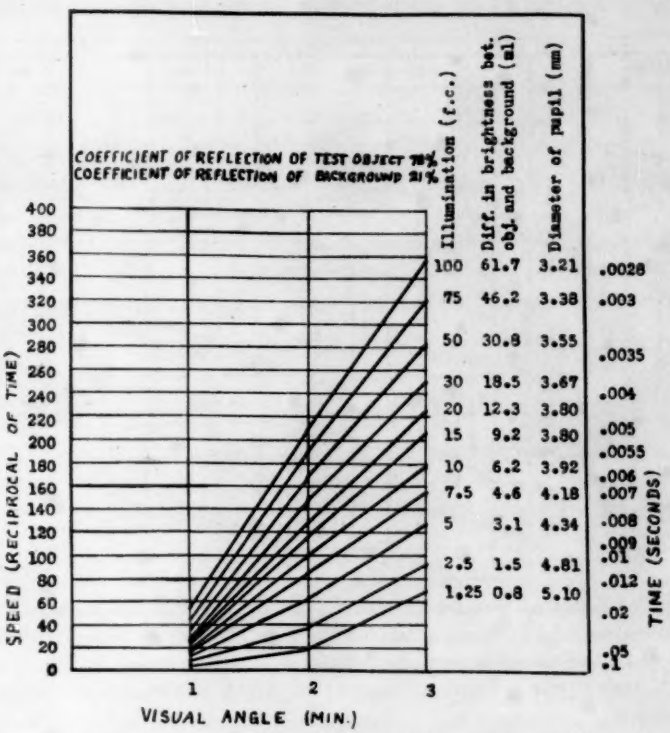


Chart 6.—Effect of increase of visual angle on speed of vision for a white test object on a gray background, coefficients of reflection, 78 and 21 per cent, respectively, at intensities of illumination ranging from 1.25 to 100 foot-candles. Speed (reciprocal of time) plotted against minutes of visual angle.

Among the points to be noted in the results given in this table, the following may be mentioned here:

1. With a given difference in visual angle the percentage change in visibility as measured by speed varies in different parts of the scale for the different intensities of illumination and for the different relations of object to background.

2. The relative or percentage increase in visibility as measured by speed is much greater between 1 and 2 minute visual angles than between the larger sizes of test object. This is true for all intensities of illumination and for all relations of object to background.

3. In passing from low to high intensities there is a general tendency for the percentage change in visibility or the relative increment for a given difference in visual angle to become rapidly smaller; the absolute increment, however, becomes larger.

4. Between 1 and 2 minutes of visual angle the percentage increase in visibility for change of size is greater for all intensities of illumination

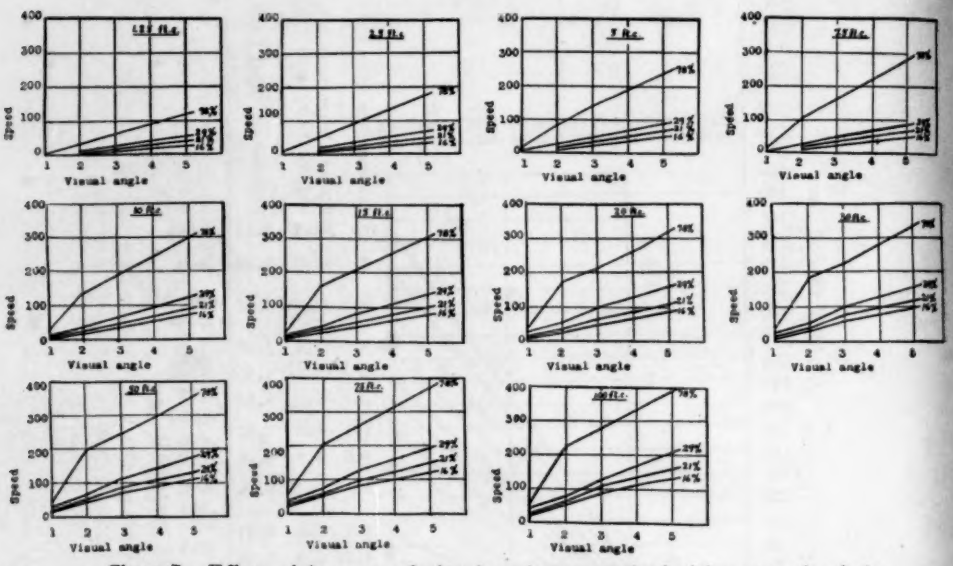


Chart 7.—Effect of increase of visual angle on speed of vision at each of the eleven intensities of illumination ranging from 1.25 to 100 foot-candle for a black test object on backgrounds having coefficients of reflection of 78, 29, 21 and 16 per cent, respectively. Speed (reciprocal of time) plotted against minutes of visual angle.

and all backgrounds than the percentage increase in size, with the exception of 75 and 100 foot-candles, background 29 per cent. Also it is greater for all sizes at the lower intensities of illumination. For the higher intensities, however, it is less than the percentage increase in visual angle between 2, 3, 4 and 5 minutes of visual angle. The intensity of illumination at which the change from greater to less occurs varies with the size of object and the relation of object to background.

5. With a few exceptions the percentage increase for the white object on the black and on the gray background is greater than for the

black object on the white and on the gray background for all intensities of illumination and all sizes on object employed.

The deviations of visibility as measured by speed of seeing from visibility rated in terms of visual angle are shown in table 12. In *A* of this table is shown a comparison of visibility as measured by speed with visibility as rated by visual angle for equal ratios of visual angle at two places in the visual angle scale; in *B*, a comparison of the ratios of measured visibility with visibility rated in terms of visual angle from point to point in the visual angle scale, and in *C*, *D* and *E*, a comparison of the ratios of measured visibility to visibility as rated by visual angle

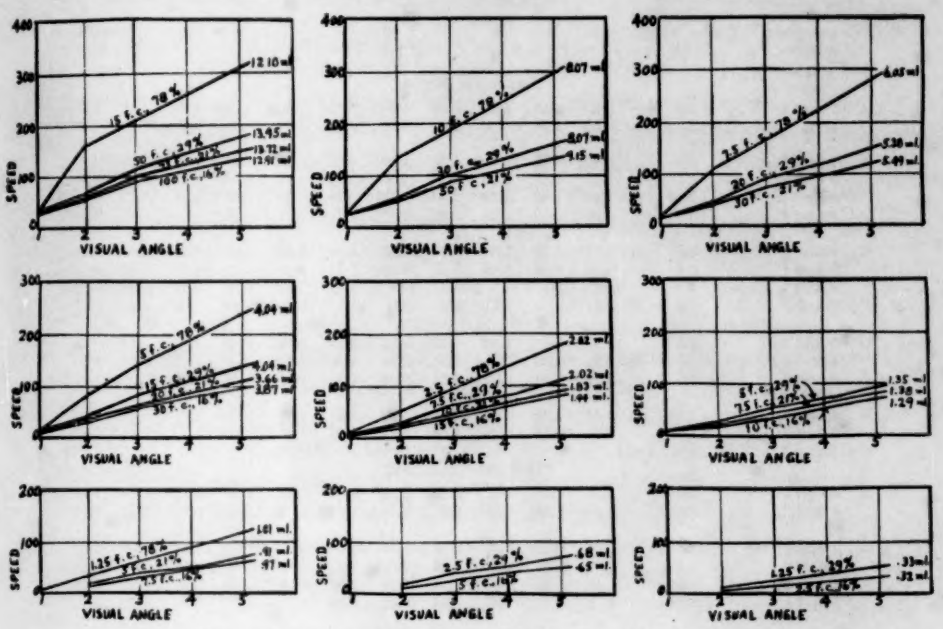


Chart 8.—Comparison of speed obtained with approximately equal differences in brightness, expressed in millilamberts, between object and background when these differences were obtained by the appropriate combination of low coefficient of reflection and high illumination and high coefficient of reflection and low illumination. Speed (reciprocal of time) plotted against visual angle in minutes.

at different points in the visibility scale when 1, 2 and 3 minutes, respectively, are taken as base.

In *A* of table 12 it will be noted that the ratios of measured visibility for equal ratios of visual angle are by no means equal. In case of the data cited the ratios for black on white are much greater in the lower than in the upper part of the visual angle scale. That is, the ratio of visibility is increased much more by an increase of visual angle from 1 to 2 minutes than by an increase from 2 to 4 minutes. This is true for

TABLE 12.—*Ratios of Visibility as Measured by Speed of Vision and as Rated in Terms of Visual Angle. In A of This Table Is Shown a Comparison of Visibility as Measured by Speed with Visibility as Rated by Visual Angle for Equal Ratios of Visual Angle at Two Places in the Visual Angle Scale; in B a Comparison of the Ratios of Measured Visibility with Visibility Rated in Terms of Visual Angle from Point to Point in the Visual Angle Scale, and in C, D and E a Comparison of the Ratios of Measured Visibility with Visibility Rated in Terms of Visual Angle at Different Points in the Visual Angle Scale When 1, 2 and 3 Minutes Are Respectively Taken as Base*

Visual Angles for which Comparison is Made		Ratio of Visibility, Visual Angle Scale	Ratio of Visibility as Measured by Speed of Vision										
			1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
			Black on White										
A	2 and 1	2.0	5.27	4.55	5.0	5.58	5.90	5.63	5.20	4.60	4.12	3.83	3.83
	4 and 2	2.0	2.55	2.78	2.30	2.04	1.82	1.57	1.51	1.49	1.51	1.52	1.50
B	2 and 1	2.0	5.27	4.55	5.0	5.58	5.90	5.63	5.20	4.60	4.12	3.83	3.83
	3 and 2	1.5	1.77	1.87	1.73	1.52	1.40	1.26	1.24	1.23	1.24	1.25	1.25
	4 and 3	1.33	1.44	1.43	1.34	1.34	1.29	1.24	1.22	1.21	1.22	1.22	1.21
	5 and 4	1.25	1.33	1.29	1.26	1.25	1.22	1.21	1.20	1.20	1.18	1.17	1.16
C	2 and 1	2.0	5.27	4.55	5.0	5.58	5.90	5.63	5.20	4.60	4.12	3.83	3.83
	3 and 1	3.0	9.30	8.50	8.65	8.45	8.27	7.13	6.4	5.65	5.12	4.77	4.73
	4 and 1	4.0	13.4	12.1	11.5	11.7	10.7	8.84	7.83	6.90	6.23	5.80	5.73
	5 and 1	5.0	17.8	15.7	14.5	14.2	13.0	10.7	9.40	8.20	7.35	6.80	6.67
D	3 and 2	1.5	1.77	1.87	1.73	1.52	1.40	1.26	1.24	1.23	1.24	1.25	1.23
	4 and 2	2.0	2.55	2.68	2.30	2.04	1.82	1.57	1.51	1.49	1.51	1.52	1.50
	5 and 2	2.5	3.38	3.46	2.90	2.55	2.20	1.90	1.82	1.79	1.79	1.78	1.74
E	4 and 3	1.33	1.44	1.43	1.34	1.34	1.29	1.24	1.22	1.21	1.22	1.22	1.21
	5 and 3	1.67	1.91	1.84	1.68	1.68	1.58	1.50	1.48	1.46	1.43	1.43	1.41
			Black on Gray, 21%										
A	2 and 1	2.0	....	....	....	3.50	3.10	3.0	2.83	2.58	2.33	2.18	2.18
	4 and 2	2.0	3.46	2.86	2.90	2.92	2.86	2.70	2.52	2.30	2.12	2.05	2.12
B	2 and 1	2.0	....	....	....	3.50	3.10	3.0	2.83	2.58	2.33	2.18	2.18
	3 and 2	1.5	2.41	2.08	2.12	2.09	2.03	2.0	1.88	1.78	1.69	1.64	1.65
	4 and 3	1.33	1.44	1.42	1.37	1.40	1.40	1.36	1.34	1.29	1.25	1.25	1.28
	5 and 4	1.25	1.39	1.37	1.35	1.30	1.26	1.26	1.26	1.26	1.22	1.21	1.19
C	2 and 1	2.0	....	....	....	3.50	3.10	3.0	2.83	2.58	2.33	2.18	2.18
	3 and 1	3.0	....	....	....	7.30	6.30	5.99	5.32	4.60	3.95	3.58	3.60
	4 and 1	4.0	....	....	....	10.2	8.85	8.14	7.12	5.95	4.93	4.47	4.63
	5 and 1	5.0	....	....	....	13.2	11.2	10.2	8.95	7.48	6.05	5.43	5.53
D	3 and 2	1.5	2.41	2.08	2.12	2.09	2.03	2.0	1.88	1.78	1.69	1.64	1.65
	4 and 2	2.0	3.46	2.86	2.90	2.92	2.86	2.70	2.52	2.30	2.12	2.05	2.12
	5 and 2	2.5	4.82	3.91	3.92	3.78	3.60	3.41	3.16	2.88	2.59	2.50	2.53
E	4 and 3	1.33	1.44	1.42	1.37	1.40	1.40	1.36	1.34	1.29	1.25	1.25	1.28
	5 and 3	1.67	2.0	1.94	1.86	1.81	1.77	1.71	1.68	1.62	1.53	1.52	1.53
			White on Black										
	2 and 1	2.0	10.5	7.70	6.20	5.08	4.78	4.36	4.30	4.40	4.35	4.32	4.28
	3 and 2	1.5	2.01	1.89	1.88	1.93	1.81	1.69	1.68	1.64	1.57	1.50	1.45
	3 and 1	3.0	21.2	14.5	11.6	9.8	8.6	7.4	7.2	7.2	6.8	6.5	6.2
			White on Gray, 21%										
	2 and 1	2.0	3.77	4.15	4.48	4.83	4.90	4.95	4.98	5.0	4.64	4.23	3.96
	3 and 2	1.5	3.57	2.49	2.02	1.86	1.78	1.76	1.75	1.70	1.67	1.68	1.69
	3 and 1	3.0	13.4	10.3	9.02	8.98	8.73	8.73	8.75	8.50	7.76	7.71	6.73

all intensities of illumination. The effect of decreasing the difference in coefficient of reflection between object and background is to make the ratios more nearly equal, i. e., to render the ratio of change of measured visibility more nearly equal throughout the visual angle scale. This also is true for all intensities of illumination.

In *B* of table 12 it will be noted that: 1. For the lower intensities of illumination and the smaller sizes of object for all relations of object to background, the ratios from point to point in the scale of measured visibilities are much greater than they are when visibility is rated in terms of visual angle. For the larger sizes of object the difference between the ratings by the two scales becomes in general progressively smaller.

2. The effect of increase of intensity of illumination is in general to decrease the ratios from point to point in the measured scale. Since there is no effect of increase of intensity on the ratings by the visual angle scale, the tendency with increase of intensity is toward more nearly equal values of the ratios from point to point on the two scales. In fact, at some points in the intensity series, depending on the value of the visual angle, the two lines of trend intersect and reverse their relationship.

3. With the exception of the change between 1 and 2 minutes of visual angle from 7.5 to 30 foot-candles, the measured values of visibility are greater for white on black than for black on white, and therefore the differences between the ratios from point to point on the visual angle and the measured scales are different for the two types of relation of object to background. The effects of increase of intensity of illumination and of decrease of difference in coefficient of reflection between object and background are in general seen to be similar for light objects on dark grounds to that for dark objects on light grounds.

In *C*, *D* and *E* of table 12, it will be noted that the lower in the scale of sizes is the value selected for the base in computing the ratios, the greater are the differences between the ratios for the scale based on visual angle and the measured scale. With a 1 minute angle as base, the differences are very great.

In chart 9 the deviations from a 1 : 1 relationship of the visibilities rated in terms of visual angle and as measured by speed are shown in the form of curves. Intensity of illumination is plotted on the horizontal coordinate and deviations from a 1 : 1 relationship between visibility as measured by speed and visibility as rated in terms of visual angle on the vertical coordinate. In plotting this relationship the base line designated by zero represents a 1 : 1 relationship between the rating in terms of visual angle and the rating in terms of speed of vision. That is, at the points in the series where the ratings on the two scales are the same, the curve will intersect this line.

Tables 13 *A* to 18 *A* have been compiled to show the relative visibilities for the different intensities of illumination and the different relations of object to background when speed of seeing is taken as the measure of the visibility of details subtending 1, 2, 3, 4 and 5 minutes of visual angle. In these tables the visibility of the detail subtending a visual angle of 1 minute is taken as 1 or unity, and the visibilities of the other sizes of object are expressed as ratios of the visibility at 1 minute.

The following points may be noted:

1. Visibilities as measured by speed of vision vary greatly with intensity of illumination and relation of object to background. No

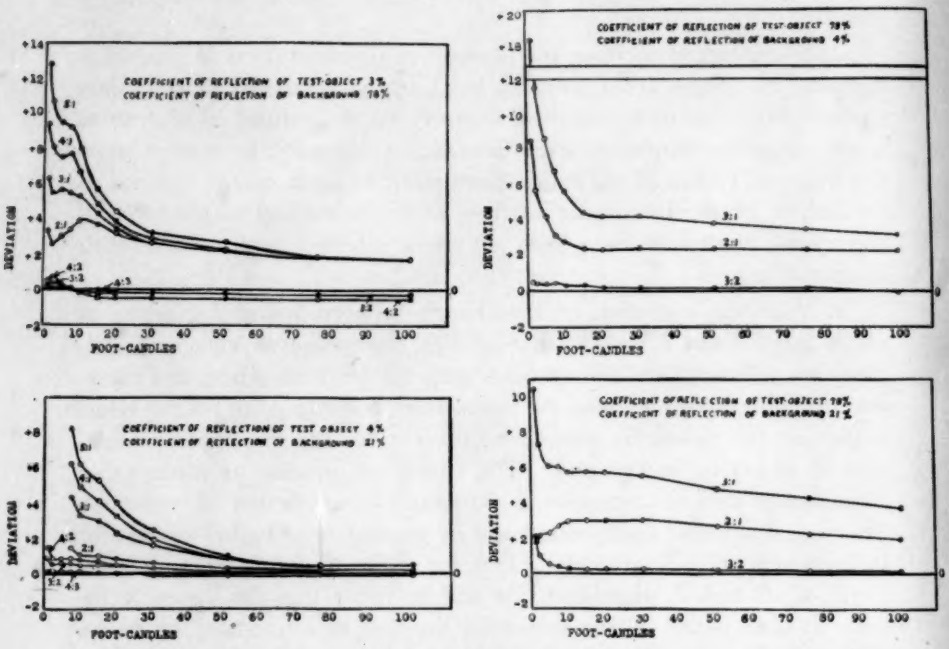

COEFFICIENT OF REFLECTION OF TEST-OBJECT 3%
COEFFICIENT OF REFLECTION OF BACKGROUND 78%
COEFFICIENT OF REFLECTION OF TEST-OBJECT 78%
COEFFICIENT OF REFLECTION OF BACKGROUND 4%
COEFFICIENT OF REFLECTION OF TEST-OBJECT 4%
COEFFICIENT OF REFLECTION OF BACKGROUND 21%
COEFFICIENT OF REFLECTION OF TEST-OBJECT 78%
COEFFICIENT OF REFLECTION OF BACKGROUND 21%
DEVIATION
FOOT-CANDLES

Chart 9.—The deviations of visibility as measured by speed from visibility rated in terms of visual angle at the different intensities of illumination for black on white, black on gray, white on black and white on gray. In these charts foot-candles are plotted on the horizontal coordinate and deviations from a 1:1 relationship with visibility as rated in terms of visual angle on the vertical coordinate. The line designated by zero represents 1:1 relationship of visibility in the two scales.

numerical provision for variation with these factors has been made in ratings in terms of visual angle.

2. Visibilities as measured by speed are in general greater for all intensities of illumination and all relations of object to background than visibilities rated in terms of visual angle. That is, the speeds for 2, 3,

4 and 5 minutes of visual angle are greater than 2, 3, 4 and 5 times the speed for 1 minute of visual angle at all intensities, and much greater at intensities less than 50 foot-candles.

3. For all sizes of object and all relations of object to background with the exception of the 2 minute white object on the gray background at the lower intensities, visibility decreases with increase of intensity of illumination. That is, the ratios of the speeds at 2, 3, 4 and 5 minutes of visual angle to the speed at 1 minute of visual angle become smaller. From this it is seen that the deviations of the ratings as measured by

TABLE 13.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and, B, the Comparative Ratings of Vision by the Two Scales. In This and the Following Tables 1 Minute of Arc Is Taken as the Base for the Ratings in the Visual Angle Scale and the Speed of Vision for 1 Minute of Arc as the Base for the Ratings in the Speed of Vision Scale. Conditions: Black Test Object on White Background, Coefficients of Reflection, Respectively, 3 and 78 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
		A. Ratings of Visibility										
1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	5.3	4.6	5.0	5.6	5.9	5.6	5.2	4.6	4.1	3.8	3.8
3	3	9.3	8.5	8.7	8.5	8.3	7.1	6.4	5.7	5.1	4.8	4.7
4	4	13.4	12.1	11.5	11.7	10.7	8.8	7.8	6.9	6.2	5.8	5.7
5	5	17.8	15.7	14.5	14.2	13.0	10.7	9.4	8.2	7.4	6.8	6.7
		B. Ratings of Vision										
1	1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.5	0.19	0.22	0.20	0.18	0.17	0.18	0.19	0.22	0.24	0.26	0.26
3	0.33	0.11	0.12	0.12	0.12	0.12	0.14	0.16	0.18	0.20	0.21	0.21
4	0.25	0.07	0.08	0.09	0.09	0.09	0.11	0.13	0.15	0.16	0.17	0.18
5	0.20	0.06	0.06	0.07	0.07	0.08	0.09	0.11	0.12	0.14	0.15	0.15

speed from those made in terms of visual angle becomes less as the intensity of illumination is increased.

4. In general, as the difference in coefficient of reflection between object and background becomes smaller, the visibilities as measured by speed become smaller for all sizes of object and all intensities of illumination. Also the deviations from the ratings in terms of visual angle become smaller.

5. With the exception of the 2 minute visual angle from 7.5 to 30 foot-candles of illumination, the visibilities as measured by speed for white on black are greater for all sizes of object and all intensities of illumination than for black on white, and for white on gray than for black on gray. Also the change with increase of intensity of illumination is greater for white on black than for black on white.

Vision as Rated in Terms of Visual Angle and as Measured by Speed of Vision.—In this section the results given in the preceding section are presented in a form which permits of a comparison of the power of seeing, or vision as it is usually called, in terms of ratings made by the visual angle scale and by speed of vision. These results are shown in tables 13 *B* to 18 *B*. In column 2 of these tables the rating is given in terms of the visual angle scale; in columns 3 to 13, in terms of speed of vision. The rating in terms of speed of vision is made on the principle that vision sustains an inverse relation to the visibility of the object that can just be discriminated. In other words, vision is taken as the reciprocal of the visibility of the smallest discriminable detail. Tables 13 *B* to 18 *B* were compiled, therefore, by taking the reciprocal of the

TABLE 14.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and B, the Comparative Ratings of Vision by the Two Scales. Conditions: Black Test Object on Gray Background, Coefficients of Reflection, Respectively, 4 and 29 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
				A. Ratings of Visibility								
1	1	....	....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	....	....	4.6	3.5	3.1	2.8	2.7	2.5	2.2	1.9	1.9
3	3	....	....	9.2	7.4	6.4	5.7	5.2	4.4	3.7	3.2	3.2
4	4	....	....	11.9	9.2	8.4	7.6	6.9	5.6	4.6	4.1	4.2
5	5	....	....	15.9	12.1	11.0	9.6	8.7	7.0	5.7	5.1	5.1
				B. Ratings of Vision								
1	1.00	....	....	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.50	....	....	0.22	0.28	0.32	0.36	0.38	0.41	0.46	0.52	0.52
3	0.33	....	....	0.11	0.14	0.16	0.17	0.19	0.23	0.27	0.31	0.31
4	0.25	....	....	0.08	0.11	0.12	0.13	0.15	0.18	0.22	0.24	0.24
5	0.20	....	....	0.06	0.08	0.09	0.10	0.12	0.14	0.18	0.20	0.20

visibilities given in tables 13 *A* to 18 *A* for details subtending 1, 2, 3, 4 and 5 minutes of visual angle at the different intensities of illumination employed and for the different relations of object to background. Accordingly, the values given show the measured ratings of vision for eyes that can just discriminate details subtending 1, 2, 3, 4 and 5 minutes of visual angle under the conditions specified.

An inspection of these tables shows the following points:

1. Vision as measured by speed varies greatly with intensity of illumination and relation of object to background. Numerical provisions have not been made for the effect of these factors in ratings made in terms of visual angle.

2. Vision as measured by speed is in general much less for all intensities of illumination and all relations of object to background than vision rated in terms of visual angle. For example, in case of a chart

with black objects on a white background under 5 foot-candles of illumination, the vision of an eye that can just discriminate a detail subtending a visual angle of 2 minutes would be rated as having 0.5 vision in terms of the visual angle scale. As measured by speed the rating would be 0.18. For a 3 minute visual angle the rating would be 0.33 on the visual angle scale and 0.11 as measured by speed of vision; for a 4 minutes visual angle, 0.25 on the visual angle scale and 0.08 on the speed of vision scale, and for a 5 minute visual angle, 0.2 on the visual angle scale and 0.07 on the speed of vision scale. It is probable, therefore, that the powers of eyes having depressed vision are greatly overestimated when rated in terms of the visual angle scale, the overestimation in case of the examples cited being approximately in the

TABLE 15.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and, B, the Comparative Ratings of Vision by the Two Scales. Conditions: Black Test Object on Gray Background, Coefficients of Reflection 4 and 21 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
A. Ratings of Visibility												
1	1	....	....	....	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	....	....	....	3.5	3.1	3.0	2.8	2.6	2.3	2.2	2.2
3	3	....	....	....	7.3	6.3	6.0	5.3	4.6	4.0	3.6	3.6
4	4	....	....	....	10.2	8.9	8.1	7.1	6.0	4.9	4.5	4.6
5	5	....	....	....	13.2	11.2	10.2	9.0	7.5	6.1	5.4	5.5
B. Ratings of Vision												
1	1.00	....	....	....	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.50	....	....	....	0.29	0.32	0.33	0.35	0.39	0.43	0.46	0.46
3	0.33	....	....	....	0.14	0.16	0.17	0.19	0.22	0.25	0.28	0.28
4	0.25	....	....	....	0.10	0.11	0.12	0.14	0.17	0.20	0.22	0.22
5	0.20	....	....	....	0.08	0.09	0.10	0.11	0.13	0.17	0.18	0.18

ratio of 3:1. Ratings based on the actual measurement of other important powers of visual performance would constitute a valuable supplement to these ratings. There seems to be little doubt that a grave injustice is done in cases of depressed vision by ratings made in terms of the visual angle scale alone.

3. For all sizes of object and all relations of object to background with the exception of the 2 minute white object on the gray background at the lower intensities, vision as rated by speed increases with increase of intensity of illumination. Since the ratings are in general smaller on the speed scale than on the visual angle scale, the effect of increase of intensity of illumination is to lessen the difference in the ratings by the two scales.

4. In general, as the difference in coefficient of reflection between object and background becomes smaller, vision as measured by speed

becomes greater for all sizes of object and all intensities of illumination. Therefore, the deviations from the ratings made by the visual angle scale become smaller with decrease of difference in coefficient of reflection between object and background.

TABLE 16.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and, B, the Comparative Ratings of Vision by the Two Scales. Conditions: Black Test Object on Gray Background, Coefficients of Reflection 4 and 16 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
					A. Ratings of Visibility							
1	1	....	....	....	....	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	....	....	....	....	3.2	3.0	3.0	2.9	2.7	2.4	2.4
3	3	....	....	....	....	6.1	5.9	5.8	5.4	4.5	3.9	3.9
4	4	....	....	....	....	9.3	8.6	8.2	7.1	5.9	5.0	5.1
5	5	....	....	....	....	12.1	11.0	10.2	8.8	7.0	6.0	5.9
					B. Ratings of Vision							
1	1.00	....	....	....	....	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.50	....	....	....	....	0.32	0.33	0.33	0.34	0.37	0.41	0.41
3	0.33	....	....	....	....	0.16	0.17	0.17	0.18	0.22	0.26	0.26
4	0.25	....	....	....	....	0.11	0.12	0.12	0.14	0.17	0.20	0.20
5	0.20	....	....	....	....	0.08	0.09	0.10	0.11	0.14	0.17	0.17

TABLE 17.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and B, the Comparative Ratings of Vision by the Two Scales. Conditions: White Test Object on Black Background, Coefficients of Reflection 78 and 4 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
					A. Ratings of Visibility							
1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	10.5	7.7	6.2	5.1	4.8	4.4	4.3	4.4	4.4	4.3	4.3
3	3	21.2	14.5	11.6	9.8	8.6	7.4	7.2	7.2	6.8	6.5	6.2
					B. Ratings of Vision							
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.50	0.10	0.13	0.16	0.20	0.21	0.23	0.23	0.23	0.23	0.23	0.23
3	0.33	0.05	0.07	0.09	0.10	0.12	0.14	0.14	0.14	0.15	0.15	0.16

5. With the exception of the 2 minute visual angle from 7.5 to 30 foot-candles of illumination, vision as measured by speed is less for white on black for all sizes of object and all intensities of illumination than for black on white; and for white on gray than for black on gray. Deviations of ratings made on the speed scale from ratings on the visual angle scale are greater, therefore, for the light objects on the dark backgrounds than for the dark objects on the light backgrounds. Obviously ratings made on charts having white letters on a black back-

ground are not comparable with those made on charts having black letters on a white background.

6. The increase in vision as measured by speed with increase of intensity of illumination is greater for white objects on a black background than for black objects on a white background.

In apparent contradiction to these comparisons, it is held by some that the rating of vision in terms of the visual angle scale is too low rather than too high. They believe that persons rated low by this scale are not as much incapacitated for the various duties they are called on to perform as the rating indicates. That point is not primarily under discussion here. Such a discussion would involve: (*a*) the determination of the importance of vision to the various types of work and activity.

TABLE 18.—*A, the Comparative Ratings of Visibility for 1, 2, 3, 4 and 5 Minutes of Visual Angle in the Visual Angle Scale and in the Speed of Vision Scale; and, B, the Comparative Ratings of Vision by the Two Scales. Conditions: White Test Object on Gray Background, Coefficients of Reflection 78 and 21 per Cent*

Visual Angle (Min.)	In Terms of Visual Angle	In Terms of Speed of Seeing										
		1.25 Ft.-c.	2.5 Ft.-c.	5 Ft.-c.	7.5 Ft.-c.	10 Ft.-c.	15 Ft.-c.	20 Ft.-c.	30 Ft.-c.	50 Ft.-c.	75 Ft.-c.	100 Ft.-c.
		A. Ratings of Visibility										
1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	3.8	4.2	4.5	4.8	4.9	5.0	5.0	5.0	4.6	4.2	4.0
3	3	13.4	10.3	9.0	9.0	8.7	8.7	8.8	8.5	7.8	7.1	6.7
		B. Ratings of Vision										
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.50	0.27	0.24	0.22	0.21	0.20	0.20	0.20	0.20	0.22	0.24	0.25
3	0.33	0.07	0.10	0.11	0.11	0.12	0.12	0.11	0.12	0.13	0.14	0.15

This varies widely. In mature persons a great many kinds of activity have become almost automatic. The totally blind, for example, are frequently able to do successfully some kind of useful work. (*b*) A rating of the value of the substitutes for vision that may be developed from other human powers and from auxiliary aids and devices. In this connection it is only fair to point out also that the scale under discussion and criticism, namely, the visual angle scale, was devised for the rating of powers of vision, not for the rating of general fitness and ability.

CONCLUSIONS

1. Size of stimulus, difference in coefficient of reflection between object and background and intensity of illumination are the three most important physical factors affecting the visibility of objects. Within the range of variation used in this paper, size of stimulus is the most important of these factors.

2. Size of object and difference in coefficient of reflection between object and background influence speed of vision in the following ways: (*a*) A less clear image is required for the discrimination of a large than a small object and of a large than a small difference between object and background; therefore less time is required for the adjustment of the focus. (*b*) The sensory effect develops more rapidly for a large than a small object and for a large than a small difference between object and background. (*c*) Less time is required in making the judgment. Intensity of illumination influences speed of vision primarily because of its effect on the visual or sensation difference between the object and its background.[2] That is, this difference increases rapidly with increase of intensity of illumination. There is a possibility also of a direct effect of intensity on the spatial aspect of the impression or the apparent size of the object.

3. Speed of vision taken as the reciprocal of the smallest interval of time in which the discrimination of the detail can be made, the time threshold of discrimination, is a sensitive, feasible and important measure of the relation of size to the visibility of objects.

4. Large increases of speed are produced at each intensity of illumination by increasing the size of the object. For the range of sizes tested there is, in general, a tendency toward a linear relationship between the size of object and the speed with which it is discriminated. That is, for a given intensity of illumination and a given relation of object to background the increment of speed corresponding to a unit increment of visual angle is for the greater part of the results approximately constant. The increment of speed varies, however, for different intensities of illumination and different relations of object to background. Intensity of illumination has an effect also on the type of relationship. At the lower intensities, the linear relationship holds for all the visual angles used. For the higher intensities a more rapid increase in speed frequently occurs between some two sizes of visual angle, the location of which varies with the relation of the object to the background. The effect of variations of this type is to cause a change in the slope of the curve.

5. The increment of speed per unit increment of visual angle is by no means proportional to the increase of visual angle, in which case the relationship between speed and visual angle would be curvilinear as it is between intensity of illumination and speed. In this connection it should be noted that the conventional rating of visibilities in terms of visual angle assumes not only that the increase of visibility is proportional to the increase of visual angle, but that the ratios of increase are equal from point to point in the two scales. This is far from true.

6. In general the speed for white objects on black is greater than for black objects on white, and for white on gray than for black on gray; also a greater increase in speed is produced by increasing the size of the light objects on the dark backgrounds than for the dark objects on the light backgrounds.

7. Increase of difference in coefficient of reflection between object and background produces an effect on speed similar to that produced by increase of intensity of illumination; that is: (*a*) the speed is greatly increased for each of the conditions tested; (*b*) the curve becomes more steeply pitched as the difference in coefficient of reflection is increased, and (*c*) the deviation from a linear relationship becomes greater as the difference in coefficient of reflection is increased.

8. With a given size and coefficient of reflection of object, equal speeds are not produced by equal differences in the amount of light reflected from object and background (*a*) when the result is obtained by the appropriate combination of small difference in coefficient of reflection and high illumination, and (*b*) when it is obtained by large difference in coefficient of reflection and low illumination. Higher speeds are obtained with large difference in coefficient of reflection and low illumination than with small difference in coefficient of reflection and high illumination. The following reasons may be cited for this difference in result: (*a*) The eye is in a different state of adaptation when the general illumination is high than when it is low. State of adaptation is an important factor in the speed of the eye's reaction. (*b*) The size of the pupil is different for a high than for a low illumination. The size of the pupil is affected by other components of illumination than those coming from the object viewed.

9. In relation to industrial and other practical situations, it may be concluded: (*a*) For the speedy discrimination of small objects there is great need for high intensities of light and large differences between object and background; (*b*) as the size of the detail to be discriminated is increased, there is less need of high intensities of illumination and large differences between object and background; (*c*) for all but sizes of object near the threshold of discrimination, light on dark is a more favorable relation of object to background than dark on light.

10. Visibility as measured by speed of vision varies greatly with intensity of illumination and with relation of object to background. No numerical provision for variation with these factors has been made in ratings in terms of visual angle.

11. Visibilities as measured by speed are in general greater than visibilities rated in terms of visual angle. From 1.25 to 50 foot-candles with large differences in coefficient of reflection between object and background, they are much greater than visibilities as rated in terms of

visual angle. That is, the speeds for 2, 3, 4 and 5 minute visual angle are much greater than 2, 3, 4 and 5 times the speed for 1 minute visual angle.

12. For all sizes of object and all relations of object to background employed, absolute visibility increases with increase of intensity of illumination. This is not true, however, for relative visibility. In case of the scale under discussion, for example, with the visibility for 1 minute of visual angle as base, the ratings at the different points in the scale in general decrease with increase of intensity of illumination. That is, the ratios of the speeds for 2, 3, 4 and 5 minutes of visual angle to the speed for 1 minute of visual angle with one exception, namely, white on gray for the 2 minute visual angle from 1.25 to 30 foot-candles, become progressively smaller as the intensity of illumination is increased. From this it follows that the deviations of the ratings as measured by speed from those made in terms of visual angle become smaller as the intensity of the illumination is increased.

13. The absolute visibilities for black on white for all sizes of object and all intensities of illumination are greater than the absolute visibilities for black on gray. With a few comparatively unimportant exceptions, this is true also in case of relative visibility for black on the gray backgrounds employed. That is, with these exceptions the ratios to the visibility for 1 minute of visual angle are greater for 2, 3, 4 and 5 minutes for black on white than for black on gray. In most cases with a black test object, therefore, the difference between the ratings by the visual angle and speed scales is decreased by the use of a gray background. Both absolute and relative visibilities are greater for white on black than for white on gray for all sizes of object and all intensities of illumination. Therefore in case of a white test object also, the difference between the ratings by the two scales is decreased by the use of a gray background.

14. With the exception of values at or near the threshold of discrimination, absolute visibility is greater for white on black for all sizes of object and all intensities of illumination than for black on white. Relative visibilities, also, are greater for white on black than for black on white for all sizes of object and all intensities of illumination with the exception of the change between 1 and 2 minutes of visual angle from 7.5 to 30 foot-candles; and the decrease with increase of intensity of illumination is greater for white on black than for black on white. With the exception already noted the differences between the ratings made by the visual angle and speed scales are smaller for white on black than for black on white.

15. The change in ratio of measured visibility for unit change of visual angle varies greatly in the different parts of the visual angle scale.

The change in the lower part is much faster than in the middle and upper parts of the scale. The ratio of increase between 1 and 2 minutes of visual angle is much greater, for example, than it is for a unit of change of visual angle higher in the scale and is much greater than the ratio of increase for visibility rated in terms of the visual angle scale. As the size of the object is increased, the difference between the ratios of increase for the two scales becomes progressively smaller.

16. Vision as measured by speed varies greatly with intensity of illumination and relation of object to background. Numerical provisions have not been made for the effect of these factors in ratings made in terms of visual angle.

17. Vision as measured by speed is in general less for all intensities of illumination and all relations of object to background than vision rated in terms of visual angle. With intensities of illumination under 50 foot-candles, it is much less than vision rated in terms of visual angle. In case of black objects on a white background with 5 foot-candles of illumination, for example, the overestimation made by ratings in terms of visual angle over a range of the scale from 1 to 5 minutes is for all values of visual angle approximately in the ratio of 3 : 1. Ratings based on the actual measurement of other important powers of visual performance would constitute a valuable supplement to these data. There seems to be little doubt that a grave injustice is done in cases of depressed vision by ratings made in terms of the visual angle scale.

18. For all sizes of object and all relations of object to background employed, with one exception, namely, white on gray for the 2 minute visual angle from 1.25 to 30 foot-candles, vision as measured by speed increases with increase of intensity of illumination. That is, the ratios of the vision at 2, 3, 4 and 5 minutes of visual angle to the vision at 1 minute of visual angle become larger with increase of intensity of illumination. From this it follows that the deviations of the ratings as measured by speed from those made in terms of visual angle become smaller as the intensity of illumination is increased.

19. With comparatively few exceptions, vision as measured by speed rates higher for both black on gray and white on gray, respectively, than for black on white and white on black for all sizes of object and all intensities of illumination. The use of a gray background thus would in general seem to have the effect of decreasing the difference between ratings made by the visual angle and by the speed scales. A substantial reduction of this difference can be obtained by the selection of the appropriate intensity of illumination and difference in coefficient of reflection between object and background.

20. Vision as rated in terms of speed is less for white on black for all sizes of object and all intensities of illumination than for black on

white with the exception of that for 2 minutes of visual angle from 7.5 to 30 foot-candles; also the increase with increase of intensity of illumination is greater for white on black than for black on white. The differences in rating between the visual angle and the speed scales are, with the exception already noted, smaller for black on white than for white on black for all sizes of object and all intensities of illumination.

21. The change in measured vision for unit change of visual angle varies greatly in different parts of the scale. The change in the lower part of the scale is much faster for the middle and upper part of the scale. The decrease in vision of an eye that can just discriminate detail subtending a visual angle of 2 minutes as rated in terms of speed is much greater than its decrease when vision is rated in terms of visual angle, for all intensities of illumination and all relations of object to background; and the difference in the rating by the two scales becomes progressively smaller for all intensities of illumination and all relations of object to background as the size of the object is increased.

22. The results obtained in this study have no direct or necessary bearing on the use of test objects graded as to visual angle in the diagnosing and correcting of errors of refraction. The objective in that procedure is to find the correction that enables the discrimination of the smallest detail. The exact rating of the test objects as to comparative visibilities is clearly of little consequence in the attainment of this objective. The grading by visual angle is sufficient to maintain the serial order of visibilities needed, provided that the other factors influencing visibility are kept constant.

23. In connection with the correction of defects in refraction, the results in question are of importance primarily in evaluating the benefits that have been obtained by the correction and their rather wide variation per unit value of scale for the different parts of the visual angle scale. They are of importance also in all cases in which questions pertaining to the rating of visibility and the power to see or vision are involved. Such questions are raised when a numerical comparison is wanted of the merits of various conditions and situations involving the use of the eye, and of the powers of vision of different persons and of a given person at different times.

24. Many other factors than the visibility of objects enter into speed and efficiency of work and many other factors than power of vision affect the ability of a person to do work. Visibility and power of vision are important factors, however, in these connections and as such should be rated as correctly as possible. Until this is done, there is little hope of arriving at even approximately correct notions or estimates of their relation to various types of fitness and efficiency.

OCULAR MOVEMENTS*

CORNELIS D. VERRIJP, M.D.
LEIDEN, HOLLAND

In this paper I do not intend to give a comprehensive exposition of the subject, but shall deal only with certain questions of kinematics on which I did some experimental work.

First, I shall present some ideas about the kinematics of rotation in general. One may describe in several ways the motion which a rectangle (fig. 1) could have made when moving from one position to a second one if one knows only these two positions. An infinite number of ways are, of course, possible but they are not equally simple for description. The motion might have consisted of two shifts and one rotation. For convenience, one may take each shift in the direction of one of the axes of reference. This is represented in figure 1, in which the heavy lines indicate the position of the rectangle at the beginning and at the end of the motion, the thin-lined rectangles being the intermediate positions. The rotation may take place around one point, appropriately chosen, in order to bring the rectangle into its final position.

I mention this way of considering the movement especially because ocular movements are often described as a combination of shifts and rotations. This description is, however, unlikely to correspond with the actual facts, and the centers of rotation described in this way (e. g., Hering's views concerning the rotation around a point fixed in space, but not fixed in the eye) are artificial. Besides, these centers are devoid of kinematic sense, because it is obvious that it is always possible to produce a change of position by means of shifts and a rotation; in that case the place of the center of rotation is absolutely undetermined, and depends solely on the direction and the extent of the shifts which may be deliberately chosen in such a way that one always gets the center in the same place.

The simplest way of describing the motion is, of course, the rotation around one single point. One can always find such a point, except when all the lines of the first position are parallel to the corresponding lines of the second position. In this case there would be only shifting, and the center may be considered to lie at an infinitely great distance.

The geometrical construction of the center of rotation is also shown in figure 1. It is easy to derive the formulas of its coordinates for the case in which one knows the position (coordinates) of one fixed point

* Submitted for publication, March 29, 1930.

* Read before the Eye Section, New York Academy of Medicine, Dec. 16, 1929.

of the object and the direction of one line in each of the positions.[1] This is one of the ways in which the positions of the rectangle may be located. In my experiments I have located the eye in this way. I shall dwell on the technic later.

I want to point to the fact that the center of rotation and the point of intersection of a certain line of the rectangle with the line that corresponds to it in the next position are not necessarily the same points, and that consequently all the experiments on ocular movements that

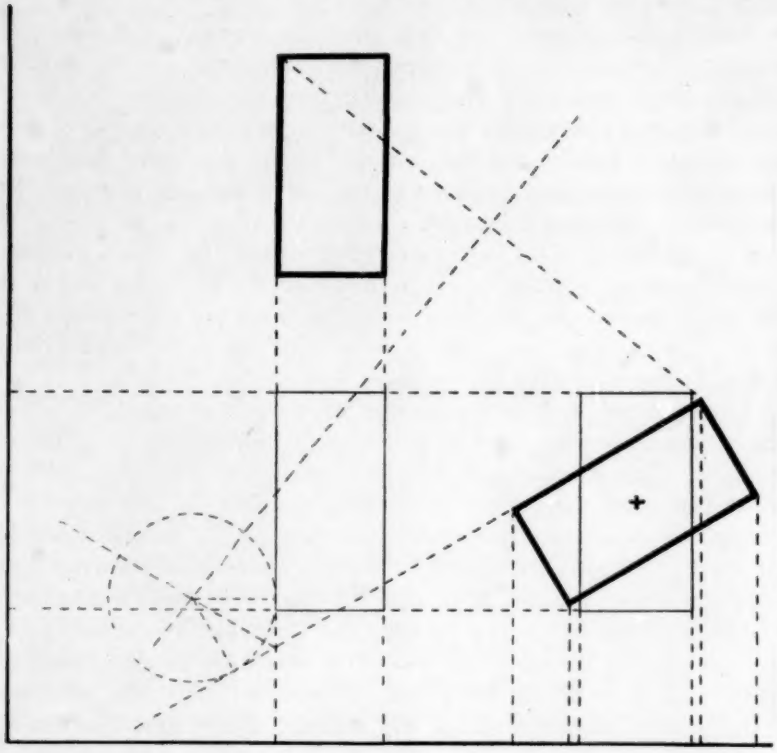


Figure 1

have determined centers of rotation as points of intersection of lines of sight and the like are worthless.

Now, suppose that instead of knowing only the two heavy-lined positions of the rectangle that are drawn in figure 1 one knows also a series of interjacent positions that the rectangle has occupied when moving from the first position to the terminal one. This series of successive interjacent positions may be the series of thin-lined rectangles

1. For the formulas and their derivation as well as for a more comprehensive description of theory and technic one may refer to Verrijp, C. D.: Proc. Kon. Akad. v. Wetensch., vol. 31, p. 357; Verhandel. d. Kon. Akad. v. Wetensch., vol. 26.

that are drawn in figure 2. The movement from each position of the rectangle to the next one might be considered as a rotation around one fixed point.

These points were constructed in the same way as was shown in figure 1. In figure 2 they are marked I, II, III, IV, V and VI. Lines are drawn from each hypothetic center to the next one, and so the path is indicated along which this continuously changing center of rotation moves. The arrow which points downward from point VI, to the left,

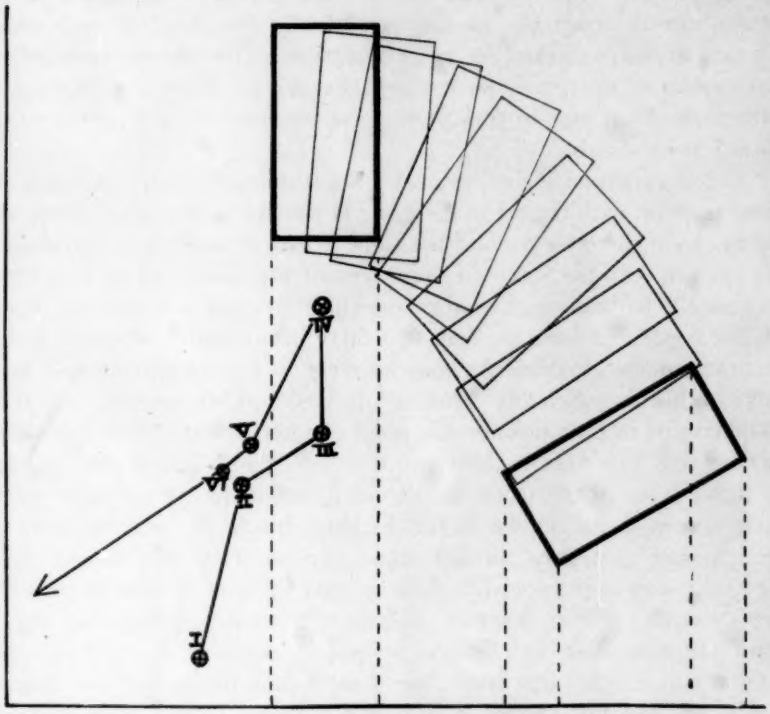


Figure 2

indicates that the next center could not be marked on the drawing, as the lines of the corresponding rectangles are more or less parallel.

Such a description grows more and more exact when the number of interjacent positions that are known grows larger and larger. If this number were infinitely large, the description would approach absolute exactness. This, of course, one cannot realize in the experiments. It should, however, be required of the experimental method that it give one the situation of the object in as large a number of successive positions as possible. By analyzing these data one finds the curve of the instantaneous centers of rotation. Not many investigators have con-

ducted their experiments on ocular movements in such a way that they really determined successive positions of the eye. It is curious to see how, in textbooks, all these unequivalent data used to be put together without mention of the different methods by which they were found.

The method that was devised by Fick and with which Müller [2] carried on his investigations meets these requirements. Here the subject looks into a vertical mirror; another vertical mirror which is inclined to the first one at an angle of 45 degrees is arranged in such a way that the subject sees in the first mirror, by means of the second one, his own eye in profile. The position of the first mirror with regard to the second one is invariable, as they are rigidly connected to each other. Vertical lines are marked on the two mirrors. The subject has to adjust this system of mirrors in such a way that the two lines always coincide with each other, and so that they are at the same time tangents to the cornea at its vertex.

If this condition is met, evidently the system of mirrors occupies the same position with regard to the eye. If the eye rotates, the system will always have to rotate around the same center or centers of rotation as the eye did. So the successive positions of the system of mirrors make it possible to analyze the corresponding motions of the eye itself. Müller concluded from his data that there is one center of rotation. The accuracy of the experiments was, however, not large enough to justify this conclusion sufficiently. Berlin [3] devised another method. He tried to determine in each position the point of intersection of two lines fixed in the eye. The first of these two lines was the so-called principal line of sight. One sights if one fixates two points in such a way that one of them is seen in the middle of the dispersed image of the other one; the straight line that runs through these two points is the line of sight. Central vision is required for sighting, and so there is actually only one line of sight. Berlin, however, in his experiments used another line of sight corresponding to a more peripheral point of his retina. The accuracy of fixating any other line of sight than the central one is much lower, and so his experiments had not much actual value however correct they might have been theoretically.

Another method was worked out by Koster.[4] This method is interesting because, through manipulation of the data, it was indirectly possible to get information about a series of successive positions of the eye. By means of a sighting apparatus, Koster determined three horizontal positions of the line of sight. For one of them the eye was in the primary position; the others were situated at the right and the left sides, at equal angles with the primary position. It is not essential that

2. Müller, J. J.: Arch. f. Ophth. **14**:183, 1868.
3. Berlin: Arch. f. Ophth. **17**:193, 1871.
4. Koster, W.: Arch. néerl. des. sc. ex. et nat., 1897, T. xxx, p. 370.

the angles are equal, but it made the computations easier. The subject first sighted for the primary position. Then the side positions were reached in the following way. The sighting apparatus was mounted on a graduated arc, along which it could be rotated; moreover, it could be shifted parallel to itself so that it could be given the suitable position; the latter was known from the amount of shifting necessary, after a certain rotation, to enable the subject to sight again. If the eye really rotated around one single center, the three lines of sight determined by

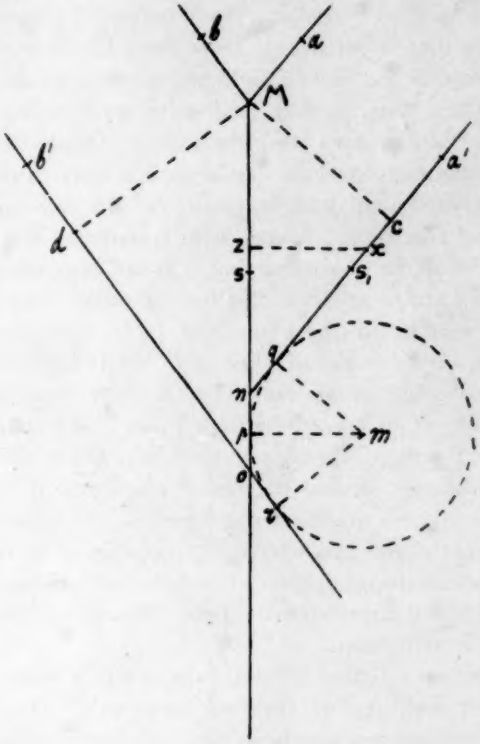


Figure 3

the three different positions of the sighting apparatus would be tangents to the same circle. A simple mathematical operation gives the description of the situation of the center of that circle with relation to the center of the graduated arc, in terms of the shifts of the sighting apparatus parallel to itself, and the angles over which it was rotated. A diagram of the method is shown in figure 3. Here, *M o* represents the line of sight in the primary position; *d o* and *c n* represent the lines of sight on the left and the right sides. *M* is the center of the graduated arc; *M d* and *M c* represent the shifts of the sighting apparatus neces-

sary to readjust it with respect to the eye after the rotation to the left and to the right sides; *m* is the center of the circle to which the three lines of sight are tangents. If the data found in this way give a different situation of the center of the circle for different angles of rotation and if the differences are larger than might be explained by the errors of the experimentation, evidence is produced that there was not one center of rotation. The difficulty in the method is, however, that if the same center-point were always found, evidence of a monocentral motion would not have been produced. This is apparent if one considers the fact that the method gives only the situation of three lines of sight, and not the part that is cut out of these lines by the eye in the corresponding positions. If the lines of sight are tangents to one circle merely, and if, at the same time, in each position corresponding points of the eye are not at equal distances from the center of that circle, the motion would not be monocentral and the eye would not have turned around that center. The experimental data, however, do not give any information about this second condition. Koster who apparently felt the deficiency in this method, while he remarked that it is not impossible that the eye moves either forward or backward in the direction of the line of sight, determined the extent of these motions. He then described ocular movements as a combination of successive shifts and rotations. This was not likely to correspond with what actually happens, but it was possible to derive from the given data (i. e., the coordinates of the several different points M found, and the shifts along the lines of sight for the corresponding positions of the eye) a series of successive positions of the eye. These are shown in figure 4. It is apparent that the path of the point of the eye which was considered is certainly not a circle, and the instantaneous centers of rotation are much scattered, without, however, showing any systematic path. Moreover, the lines of sight do not intersect in one point.

In my experiments I tried to locate the eye in a series of successive positions without making any previous assumption about a center of rotation. Another assumption, however, was made, i. e., that without sensible deviations the eye may make movements in which all the points of it describe paths parallel to a flat plane. One may assume that this is practically true, at least for the horizontal and the vertical plane, if the starting position for the motion upward and downward and to the left and the right side is the so-called primary position of the eye. Listing's law, in which this principle is stated, does not hold absolutely, especially for larger angles of rotation, as a certain amount of rolling around the line of fixation accompanies the movement. It may be assumed, however, that at least for the angles that come into consideration the deviations do not influence the results sensibly. In the experi-

ments, therefore, the points of the eye were supposed to make motions practically parallel to that horizontal plane in which the line of sight lies in its primary position. The eye was located each time by the position of one fixed point connected with it and by the direction of one fixed line in it. I mentioned that I worked out formulas that give the relations between the coordinates of the fixed point and the angle of rotation on one side, and the coordinates of the corresponding instantaneous center of rotation on the other side.

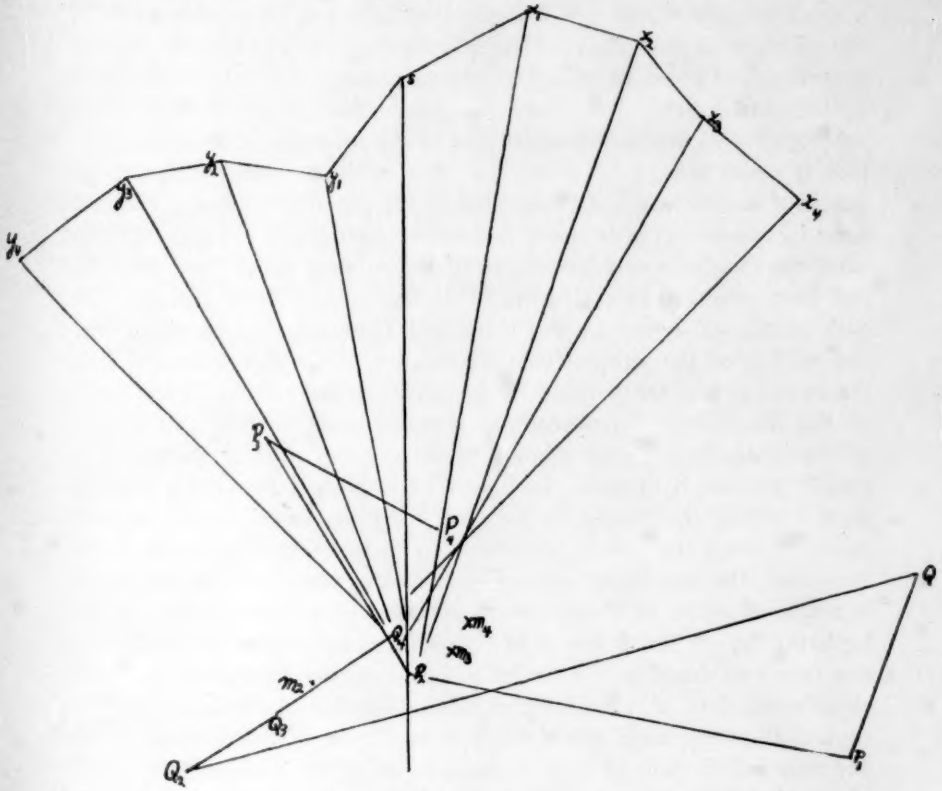


Figure 4

I took the line of sight as the fixed line from which the direction had to be known. The subject looked through a cross-shaped opening in a brass plate which was mounted at a distance of about 15 cm. from his eye; 15 cm. behind this plate a cross formed by black lines was mounted. The act of sighting consisted in seeing this second cross in the middle of the dispersed image of the edges of the cross-shaped opening. The accuracy with which practically the line of sight may be located in the eye or, conversely, the eye may be located by means of the line of sight, is easily found by ascertaining the exactness with which a certain posi-

tion may be reproduced in sighting. In the experiments this reproduction turned out to be possible within an angle of about one half of a minute. The sighting apparatus was given the required direction by means of a theodolite on which it was built, and the required position in the anteroposterior and transverse directions by means of a cross-support with carefully calibrated screws.

The horizontal projection of a vertical spider-thread constituted the fixed point connected with the eye. This spider-thread was attached to a small telescope from which the optical axis was perpendicular to the line of sight of the subject. The telescope was attached to the sighting apparatus and could be moved by means of the screws of a small cross-support of its own. The observer focused the anterior surface of the subject's cornea in this telescope, and as the telescope contained a cross-hair it could always be given the same position with relation to the image of the cornea, i. e., tangential to the anterior surface. This was done by the observer in every successive position of the subject's eye, after the theodolite and the screws of the support which bore the latter had been arranged in such a way that the subject sighted again. The path of the spider-thread was calculated from the data obtained from the motions of the screws, from the rotation of the theodolite and from the knowledge of the position of the spider-thread relative to the center of the theodolite. Supplementary measurements showed the position of the spider-thread with relation to the eye. A path of the eye itself could therefore be drawn. In figure 5 this path is shown for a movement covering 60 degrees, in steps of 3 degrees each. Circles may be drawn through the points, and many of them lie near to those circles. Moreover, the way in which the instantaneous center of rotation moves is not systematic, as these centers seem to be scattered more or less haphazardly. A first view would therefore suggest the probability of one center of rotation, the deviation being caused by the errors of the experimentation. A consideration of these errors in maximo, however, showed that they could explain only a small part of the deviations. So one must admit that, at least in these series of experiments, the center of rotation was an ever-changing one, and that only practically might one speak of one center of rotation, the coordinates of this center being the averages of the coordinates of the instantaneous centers.

The investigations were only indirectly concerned with another circumstance which complicates the actual motion somewhat more, i. e., the fact that the eye perpetually makes small motions during fixation. These were studied by several investigators in several different ways.[5]

5. Oehrwall, H.: Skandinav. Arch. f. Physiol. **27**:65, 1912. Marx, E., and Trendenlenburg, W.: Ztschr. f. Sinnesphysiol. **45**:87, 1911. Marx, E.: Ztschr. f. Sinnesphysiol. **47**:79, 1913. McAllister, C. N.: Monograph Supplements of the Psychological Review, March, 1905, vol. 7. Dodge, Raymond: Ztschr. f. Psychol. **52**:321, 1909.

It is difficult to say how much bearing the results they obtained have on the experiments that are described here, as, on the one hand, those movements were studied for the fixation of a point only and not for sighting, which is a more complicated process, and, on the other hand, fixation of the head was never very solid. Moreover, the results that these authors secured differ very much from each other as they vary from five to about forty minutes. In order to explain the fact that

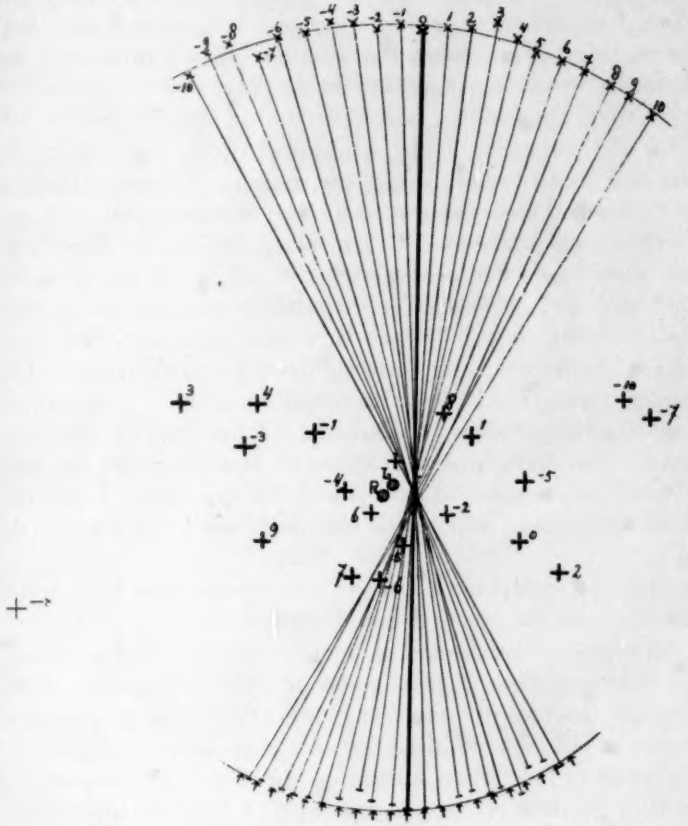


Figure 5

the eye fixates notwithstanding these movements, the authors assumed that there is a certain area in the retina over which elements are equivalent for fixation. This is indeed probable for other reasons, the explanation of which would take too much space.[6] On the other hand, the fact of the movements in itself does not necessitate the assumption of such an area, or at least not the assumption of an area of a correspond-

6. Hecht, Selig: The Relation Between Visual Acuity and Illumination, J. General Physiol. **11**:275, 1928.

ing extent. These movements are very fast, and there are alternating pauses; Oehrwall, especially, pointed to this fact. It may be possible, therefore, that the retina is stimulated only during the pauses, which would be sufficient to give an impression of continuity. The same alternation of pauses and rapid motions happens in reading. As explained, these experiments were not done for the sighting eye; the act of sighting is different from the mere act of fixating a point, which involves probably fewer elements of the retina; so the accuracy of sighting, which I mentioned is within about one-half minute, does not give any direct information about the question of a central area in which the elements would be equivalent for fixation.

To some extent the small movements during fixation might be responsible for the variability in the adjustment of the telescope with which the observer focused the cornea of the subject. When the fixation of the subject remained constant, the position of this telescope could be reproduced within about 0.01 mm. This involved, besides the difference caused by the mobility of the eye, the error made by the observer in adjusting the telescope. Eventual anteroposterior compounds of the small movements during fixation which have been mentioned have not been investigated especially. Anteroposterior movements caused by heart beat and respiration have been described, however.[7] Although I did not observe regular pulsations, I would not *a priori* deny an influence of these causes. The more important cause is, however, probably the dependence of the anteroposterior position of the eye on the width of the slit between the eyelids, which was first described by Müller [8] and by Donders.[9]

The fact that the instantaneous center of rotation may have considerable mobility bears on practical questions as well.

In fact, the notion of the center of rotation of the eye has found application in ophthalmology, e. g., in methods that try to locate, with roentgen rays, the position of a foreign body, while photographs are taken of the eye in different positions; or in computations for glasses, which are supposed to give sharp images on the retina not only when the eye looks through their center, but also when it looks through their periphery. In these computations it is assumed [10] that the center of rotation has a definite position, or that at least the deviations from that position are small enough to be neglected. As, however, an anlysis of the motion of the eye had never been done, it seems to me that this

7. Tuyl, A.: Graefe's Arch. **52**:99, 1871.

8. Müller (footnote 2, p. 205).

9. Donders, F. C.: Graefe's Arch. **17**:99, 1871.

10. Weisz, E.: Centralzeitung f. Optik. u. Mechanik **41**:321, 337, 354 and 369, 1920.

assumption lacks real foundation. Even if for every patient one would introduce in the formulas an individual anteroposterior distance of the center from the cornea, instead of an "average" one, there would be no correction for the possible spread of the instantaneous centers which I showed. I would not be surprised if this spread was large enough [11] to explain the troubles that patients have with their glasses, which are supposed to be "achsensymmetrisch" and to make point-for-point images.

11. In the experiment yielding the data that are represented by figure 5, the breadth of the area that is covered by the instantaneous centers is about 20 mm. The bundle of lines represents the positions which an anteroposterior line in the eye occupies in the successive positions of the eye which were analyzed, from 30 degrees to the left side to 30 degrees to the right side. These lines have been drawn through up to the crossing-point with the retina. The small arrows indicate the corresponding positions which this crossing-point would occupy if the eye had rotated around one average center of rotation.

ANOMALIES OF ACCOMMODATION

THEIR FREQUENCY AND VARIETY *

THOMAS D. ALLEN, M.D.
CHICAGO

A study of 5,000 case records was recently made to ascertain how frequently weakness of accommodation was found. It developed into a most interesting piece of work because it revealed certain surprises, a few of which will probably be of sufficient interest to warrant a paper.

The points noted in the examination were as follows:

1. Name, age and occupation; history, complaint and objective examination.
2. Vision without present glasses, with glasses, and by manifest refraction; a record of various previously purchased glasses, date of purchase and whether or not refraction was by cycloplegic.
3. If vision was 6/12 or better, the near point of accommodation was measured.
4. Muscular balance, duction tests and near point of convergence.
5. Dark room examination.
6. Examination with cycloplegic, objective and subjective.
7. Final test a week later (if atropine was used, two weeks later). Glasses ordered; patient requested to return with glasses.
8. Checking of glasses.

At subsequent examinations, it was not always deemed necessary to use a cycloplegic.

In measuring the accommodation, Duane's rule was used because of its simplicity. The near point was taken as the farthest point at which the finest print that the patient could read began to blur. For a time the Duane line was used, a finely engraved line 0.2 by 3 mm. on a small white card, but the card became soiled easily. It was found that for all practicable purposes the small print on a washable celluloid card gave the same result, and the blurring of a fine letter such as a small case *"a"* or *"e"* was readily appreciated.

Naturally, each eye was examined separately. The reading card was held by the patient at the point where it was most easily read, the punctum optimum. Then the rule was placed with its zero on the plane of the glasses, i. e., at the anterior focus of the eye, and the card was carried along the rule until the near point was reached. This was repeated a number of times to make sure that the result was constant, and to be certain that the patient comprehended what was wanted. If it was inconstant, there must have been a reason. If the inconsistency consisted in a definite recession of the near point, that fact was recorded.

* Submitted for publication, April 3, 1930.

* From the Ophthalmological Department, Rush Medical College.

Because there is no objective method for determining the accommodation, there must be no distraction; therefore, the simpler and easier the test is made, the more accurate will be the readings. This is one reason that the Duane rule is used.

For this paper my co-workers and I have arbitrarily limited ourselves to changes found in patients between the ages of 18 and 42, with the exception of a few instances, because in patients younger than 18 it unfortunately was not our routine to make this examination, and in those more than 42, the low normal accommodative amplitude is less than 3 diopters. Forty-two per cent of our patients fell within this age range. In 65 per cent of these refraction was done under cycloplegic. The rest had cases of foreign body, conjunctivitis, cataract, uveitis and glaucoma or came for consultation, etc. If there was some doubt as to whether the correct age was given (as, for example, a woman evidently 45 years old claiming to be only 35), or as to the patient's comprehension of what was wanted, or if the cycloplegic refraction showed enough latent hyperopia to explain a considerable portion of the accommodative weakness, we have not included the record.

In the cases reported the condition was not caused by cycloplegic, as the accommodation was measured before the pupils were dilated, or a full week after the administration of homatropine, and from two to three weeks after atropine was used. Furthermore, the records of several cases were found in the files in which atropine had been given for iritis, etc., and in which the patients were found subsequently to have normal accommodation; we have been unable to find a single case in which we considered the remotest relationship between a previous cycloplegia and subsequent accommodative weakness.

In order to study the anomalies of accommodation, it is necessary to review the normal observations. In the accompanying chart the results of tabulations of many apparently normal persons are shown. The maximum, minimum and mean region and amplitude of accommodation are plotted in four year periods for patients from 8 to 72 years of age. Deviations from these normals are problems to be studied.

The classification of Duane is accepted by de Schweinitz and others, and is as follows: (*a*) too low accommodation, (*b*) too high accommodation, (*c*) inertia of accommodation and (*d*) unequal accommodation.

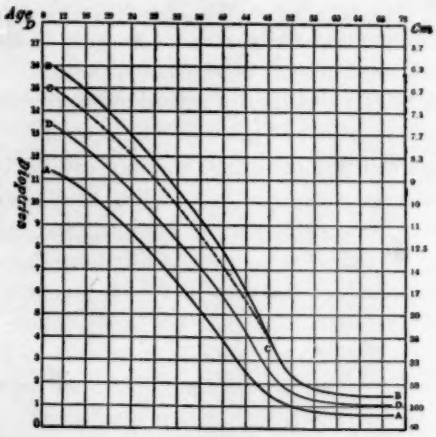
In this review of about 5,000 records, we collected more than 100 which we classified more practically, we think, as follows:

1. Premature presbyopia, i. e., in patients between 40 and 50 years who had lost more elasticity of the lens than is to be expected.
2. Insufficiency; the accommodation is always below the lower limit.
3. Ill sustained; the accommodation is normal at first, but soon gives out.
4. Inertia; difficulty is experienced in changing from one accommodation state to another.

5. Inequality; the accommodation of the two eyes is not the same.

6. Excessive; the accommodation is persistently above the normal limit.

There can be subdivisions in this classification according to the etiology, age or amount. For instance, it seemed a little easier to study the grouped cases if we divided the second and third groups into those found in patients less than 25 years and those in patients more than 25 years of age. Then, too, on a probable etiologic basis, we found it rather easy and interesting to make the following subdivisions for study: those associated (1) with anisometropia and advancing myopia, (2) with other ocular abnormalities, (3) with weakness of convergence, (4) with cerebral anomalies, (5) with general debilitating conditions and (6) with severe or prolonged close work.



Results of tabulations of apparently normal persons from 8 to 72 years of age. *A* indicates minimum in apparently normal patients; *B*, extreme maximum; *C*, maximum, and *D*, mean.

The following is a list of the associated pathologic conditions: congenital malformations, cataract, foreign body in lens, optic neuritis, anisometropia, myopia, (epidemic) encephalitis, syphilis of the central nervous system, Argyll-Robertson pupils, weakness of the interni, weakness of convergence, diphtheria, psychosis, psychasthenia, migraine, chronic appendicitis, infection of the antrum, nasal congestion, injury to the head, severe and prolonged close application and large ingestion of sugar.

In all, we found more than 100 cases of unquestioned anomaly; that is, this condition occurred in 2 per cent of our patients. Forty-three per cent of our patients were males; yet 55 per cent of these particular anomalies were found in males.

Only a brief résumé of the main points in one or two cases in each of the divisions of accommodative weakness is given.

RÉSUMÉ OF CASES

1. *Premature Presbyopia (Nine Cases).*—In this division, it was difficult to exclude even moderate abnormalities; the normal and the pathologic conditions are less easily differentiated. J. F. R., aged 42, seen in 1922, had had three pair of glasses in five years. At the time of examination, he was wearing a + 1.50 spherical lens. Vision in the right eye with + 0.75 sphere, + 0.25 cylinder, axis 45 degrees, was 6/6. A + 2.25 lens was added for a near point of 31 cm. Vision in the left eye with + 0.50 sphere, + 0.25 cylinder, axis 135 degrees, was 6/6. Addition of a + 2.25 lens was required for a near point of 31 cm. To obtain a near point of 31 cm. one must use 3.2 diopters of accommodation. As this patient required an addition of a + 2.2 diopter sphere to give him this near point, his own accommodation was only 1 diopter. The normal for a person 42 years of age is 5; the minimum is 2.7 diopters. Therefore, he had 4 diopters less than the normal and 1.7 less than the minimum in accommodative power. Cycloplegic (homatropine) refraction was done. Latent hyperopia, 0.25, 1 degree esophoria and 1 degree hyperphoria were found. The media were clear, and the fundi were normal. Four months later, the same observations were noted. Seven years later, a greater addition was required.

2. *Insufficiency in Patients Less Than 25 Years (Twelve Cases).*—The usual complaint in this condition is itching of the lids and asthenopia on reading. E. M. H., Jr., a school boy, aged 18, was seen for the first time in 1925. He has been a patient for four years. The diagnosis was very low grade myopic astigmatism. The myopia increased only 0.5 diopter in three years (homatropine). Vision in the right eye with glasses was 6/6 +, and the near point was 20 cm. (accommodation, 5 diopters); that in the left eye with glasses was 6/6 +, and the near point was also 20 cm. As the normal minimum for this age is 9.5 diopters, there was a deficiency of 4.5 diopters. The patient has been seen regularly since then; the condition remains the same.

Insufficiency in Patients More Than 25 Years (Nine Cases).—B. H. N., aged 32, a graduate student at the University of Chicago, was seen in 1922. An optician had given him a correction of — 2.25 cylinder, axis 180 degrees, for the right eye and — 2.50 cylinder, axis 180 degrees, for the left eye. He complained of irritation of the eyes and diminishing vision during the few months before examination. Vision in the right eye with glasses was 6/6, and the near point was 22 cm. (4.5 diopters); that in the left eye with glasses was 6/9, and the near point was 24 cm. (4.1 diopters). As the minimum is 6 diopters, there was a deficiency of from 1.5 to 1.9 diopters. There was 1 degree of esophoria for distance and 3 degrees for the near point, and the near point of convergence was 80 mm. Five years later he returned for the cycloplegic refraction, which checked within less than 0.5 diopter. Vision was about the same, but the near point was 35 cm. for the right eye and 32 cm. for the left (about 3 diopters). The minimum for the age of 37 is 4.75 diopters. As a result of the administration of homatropine, one lens was slightly altered, and the glasses were worn with comfort.

3. *Ill Sustained in Patients Less Than 25 Years (Eight Cases).*—R. A. B., aged 21, was seen in 1929. At that time he was wearing a — 0.50 cylinder, axis 180 degrees for the right eye and a — 0.12 spherical lens for the left eye, fitted by an optician four months before the present examination. The patient had always done fine drawing. Six months previous to examination, he had influenza. On recovery, the eyes were weak. Glasses seemed to help for a time. He had persistent occipital headache. He said that vision "fades." Manifest refraction later verified by cycloplegic examination showed less than half a diopter of hyperopic astigmatism in each

eye. Vision was normal in each eye. With glasses the near points for the right eye were 14, 17, 20, 22, 25, 28 and 30 cm.; for the left eye, 14, 16, 18, 20 and 22 cm. This was verified by the addition of a spherical lens and retesting. In repeated tests for accommodation the eyes tired easily. The deficiency was 1.7, tiring to 5.5 diopters. The media were clear, and the fundi were normal.

Ill Sustained in Patients More Than 25 Years (Ten Cases).—Dr. V. M. L., aged 32, was seen in 1923. There was blurring of vision after closing or pressing on the eyes or lids. He wore a —1.88 spherical lens for the right eye and a —2.00 sphere, —0.38 cylinder, axis 175 degrees, for the left. Vision in the right eye with glasses was 6/6, and the near points were 19, 21, 23 and 24 cm.; that in the left with glasses was 6/6, and the near points were 16, 18, 19, 21 and 22 cm. On refraction with homatropine, a slight change was found; there was a deficiency tiring to 1.9 diopters. In 1930, at the age of 39, vision was the same. The near points for the right eye were 23, 24, 25, 27, 26, 27 and 28 cm., and for the left, 25, 26, 28, 30, 31, 32 and 31 cm. Occasionally, the patient removed his glasses to read.

4. *Inertia.*—No cases of inertia were found.

5. *Inequality (Ten Cases).*—G. N., aged 14, was seen in 1922. The eyes tired after reading a short time. Vision in the right eye was 6/6 +, and the near points were 10, 12, 13, 14, 15 and 16 cm. Vision in the left eye was 6/6 +, and the near point was 21 cm. constant. The inequality was 1.2 to 5 diopters. Orthophoria was present. The media were clear, and the fundi were normal. Refraction was done with homatropine. Cylindric lenses of 0.5 diopter with a 90 degree axis were ordered.

G. M. L., aged 23, was seen in 1922. Some years before he had passed the aviators' examination of the United States Government. Just previous to the time of examination he became drowsy on reading, and dull pain was present in the eyes. Vision in the right eye was 6/9; with glasses of +0.75 cylinder and an axis of 80 degrees, vision was 6/6, and the near point, 20 cm. (5 diopters). Vision in the left eye was 6/12; with glasses of +1.00 cylinder, axis 105 degrees, it was 6/6 +, and the near point was 14 cm. (7 diopters). These results were corroborated with homatropine. Orthophoria was present. Full correction was ordered. The inequality was 2 diopters.

6. *Excessive Accommodation (1 Diopter More Than Maximum) (One Case).*—P. P., aged 41, a farmer, was seen in 1928. He always had difficulty in keeping his eyes open. During the summer previous to examination, he ran after a cow and was exhausted for a time. Since then the eyes had been wider open than usual. The sclerae showed from 1 to 2 mm. above the upper limbus; the upper lids lagged on looking down. The pulse rate was 90. The pupils were 4 mm. round and reacted well. The exophthalmometer measured 18.5 for the right and 18 for the left eye. There was no heart trouble, edema of the extremities, etc., and no glycosuria. Vision in the right eye with —1.00 cylinder, axis 30 degrees, was 6/4 and the near point was 12 cm. (8 diopters, 1 more than maximum); that in the left eye with —0.50 cylinder, axis 135 degrees, was 6/4, and the near point was 12 cm. (8 diopters, 1 more than maximum). This observation was corroborated with homatropine. The patient had incipient cataract in both eyes. At present he is being treated by his own physician.

7. *Unclassified.*—Miss C. C. W., a Chinese woman, a student in the department of physiology at the University of Chicago, had been trying out her sugar tolerance. Whether from that or from lack of sleep (she had denied herself her accustomed rest for weeks), she required a +1.00 diopter lens to give her a near point of 30

cm., although she was but 30 years of age. Under refraction with homatropine, only a quarter diopter cylinder was found necessary.

Miss E. C., aged 31, was seen in 1930, with —6.00 spherical lens, —1.50 cylinder, axis 15 degrees, for the right eye and —6.00 spherical, —2.00 cylinder, axis 150 degrees, for the left eye. She had been a patient for ten years; she had nonprogressive myopia. Three refractions were done with cycloplegic and three without this agent. During January and February, 1930, she was ill at Michael Reese Hospital with headaches, delirium and fever, and was under the care of Dr. S. Straus and Dr. Lewis Pollock. While ill, she could not read; all letters and words were pied. The left orbital rim had been injured (golf stick) during the previous summer; at the time, she was unconscious for from fifteen to twenty minutes. Recovery apparently was complete. The diagnosis at the hospital was "myoclonus—probably hysteria." She had had a former attack and had been at the Presbyterian Hospital, where a similar diagnosis had been made by Dr. Bassoe about two years before. In March, 1930, vision in both eyes with glasses was 6/6; a +1.00 diopter lens was added to give a near point of from 25 to 35 cm. (4 to 3 diopters). Her accommodation was from 3 to 2 diopters. The minimum for the age of 31 is 6.2 diopters; hence there was a deficiency of from 3.2 to 4.2 diopters. The fields were normal. A myopic conus was the only pathologic change noted in the fundus.

CONCLUSIONS

It has been demonstrated that anomalies of accommodation are frequent, occurring in 2 per cent of the cases in a general ophthalmic practice. The few examples given are samples, not extremes, of more than 100 cases recently reviewed. By having a classification similar to one of those suggested, it will be easier to study the patient for the purpose of correcting or alleviating the condition.

OBSCURE SYMPATHETIC PHENOMENA

REPORT OF TWO CASES *

GEORGE LINDSAY JOHNSON, M.D.
DURBAN, SOUTH AFRICA

Notwithstanding the great amount of attention that has been directed of late years to the subject of sympathetic ophthalmia and sympathetic phenomena generally, ophthalmologists are still far from arriving at a thorough understanding of the causes that induce these conditions. It is only by collecting facts that the desired explanation can ultimately be found. Therefore, I think that it is the duty of ophthalmologists to record any cases presenting peculiar or unusual features. That is why I venture to publish my notes on the cases of two patients who have recently come under my care.

Many years ago, Dr. Mules of London introduced the practice of eviscerating the eyeball, in lieu of extirpation, and afterward inserting in the place of its contents a hollow glass ball, which was kept in position by sutures through the cut edges of the conjunctiva.

As several cases of sympathetic ophthalmia were reported as the result of this operation, Mr. Frost afterward suggested a valuable modification thereof, which Mr. Lang put into practice. He removed the eye in its entirety, and replaced it by a hollow glass ball, which he kept in place by sewing the conjunctiva directly over it, the whole operation being performed, of course, under aseptic precautions. I have not been able to ascertain that any cases of sympathetic trouble have been recorded since this method has been practiced, and I hardly thought that such trouble would arise until the patient in case 1 came to my consulting rooms.

REPORT OF CASES

CASE 1.—*Sympathetic irritation caused by the presence of a glass ball inserted behind the conjunctiva in the place of an eye that had been removed on account of a detached retina due to an intra-ocular growth.*

Charles W., aged 42, first came to see me on February 3. Two years previously he had had the left eye removed for an ocular tumor with retinal detachment. The surgeon inserted one of Mules' glass balls, a hollow ball 2 cm. in diameter. This was not inserted into the eviscerated sclerotic, but into the empty socket, and the conjunctiva was sewn over it. As far as the operation went, nothing could have been more satisfactory. The conjunctiva united perfectly, leaving no trace of a wound. The glass ball could be seen as a faint bluish-white body underneath the conjunctiva. The ball with the conjunctiva over it was capable of a trifling movement, about 1 mm. each way. The patient had good vision in the right eye, 6/6, and he could read Jaeger's test type no. 1 without

* Submitted for publication, March 19, 1930.

glasses. On examining the eye, I noticed a slight conjunctivitis and a faint pinkish scleral zone reaching to the edge of the cornea. He informed me that this redness often disappeared for a day or two, and then reappeared. The tenson was normal. On taking his field of vision, I noticed that it was considerably contracted, but, curiously enough, the contraction varied from day to day, and I even observed a difference if I repeated the examination within a few minutes.

On pressing the conjunctiva gently over the glass ball, the patient complained of a sharp pain which was referred to the back of the eye. On examination with the ophthalmoscope, I noticed nothing abnormal. The fovea appeared as a bright yellowish dot. The disk had the normal healthy pink color, although there was a physiologic cup.

He stated that he had no visual trouble until about two months previously, when he noticed that his sight "came and went." While working, he found that after some time the sight would get blurred. This occurred especially toward evening, often several times during the space of an hour. Occasionally nothing would occur for two or three days, and then the disturbances of vision would return with increased persistency. He also became more and more deceived in regard to the distance and position of near objects. Among other duties he had to pour ale for customers, and during the last two months he had repeatedly poured the ale on to the table, not being able to judge the position or distance of the glass. This might be ascribed to the removal of the left eye, whereby he was deprived of the information which convergence and stereoscopic vision afforded regarding the distance and position of objects, but this explanation could not be accepted, as his eye had been blind two years before its removal, and he had not noticed this defect until quite recently, except during the first two months after the enucleation. Moreover, after the enucleation, he was wont to be greatly deceived regarding the size of objects; at the time of examination, however, he could judge the size very well, although he was invariably mistaken as to the distance. I assured myself of this fact by a variety of tests.

He had also been troubled with seeing the edges of letters and other objects blurred, especially when seen in artificial light. On looking at a book, he found that his accommodation failed him after a few minutes, so that he had to hold the book farther from him to be able to see clearly, and even then the letters soon began to blur and ran into one another.

The patient had always been steady. He drank very little alcohol and did not smoke.

On February 14, I removed the glass ball by a transverse incision through the conjunctiva stretched over it, and after washing out the cavity of the orbit with sublimate solution, I left the wound to heal without any stitches. I failed to see any trace of the stump of the optic nerve.

On July 14, the patient returned saying that ever since the removal of the glass ball the sight had been improving, and nearly all the symptoms had vanished. For one month after the removal, he noticed that everything had a double outline, the one fainter than the clear image. He also noticed this reduplication chiefly when looking at bright objects, especially if seen against a bright background. By the middle of August the reduplication had entirely disappeared. He also at first noticed repeated flashes of light, which he referred to the socket. He had full accommodation; his vision was 6/6, and he could read Jaeger's test type no. 1 without glasses; all symptoms had disappeared.

It is worthy of note in this case that although the eyeball had been completely removed and no traces of the stump of the optic nerve could

be perceived, the patient suffered from spasmodic failure of accommodation, flashes of light, diminution of the field of vision, momentary loss of sight and occasional conjunctivitis and ciliary injection. After removal of the glass sphere, all the foregoing symptoms disappeared.

CASE 2.—*So-called sympathetic keratitis.*

This case presents some peculiar features, and prima facie it appears so improbable that had it not been carefully and independently corroborated by five other physicians who saw the case both in my presence and without my being there, I should have hesitated to record it.

Charlotte B., aged 39, had on several previous occasions during the last five or six years been under treatment for chronic iritis with extensive adhesions and nebulae of the cornea. When I first saw her on March 31, I found the following signs and symptoms. Both corneas were infiltrated with extensive nebulae, so much so that although both irides were plainly visible around their whole extent, the cornea of each eye was clear only in one place. The patient could count fingers only at a distance of 2 meters with the right eye and 1 meter with the left. The irides were semicontracted, and the right eye did not respond to light, owing to the extensive adhesions. I therefore admitted her to a nursing home with a view to making an iridectomy downward in the right eye and inward in the left, for these were the only two places where the corneas were clear.

I found great difficulty in performing the iridectomy in the right eye, owing to the adhesions of the free edge of the iris to the lens capsule. I ultimately succeeded without rupturing the capsule, but I left a small ring of iris pigment adhering to it. The eyes were bandaged immediately after the operation. Four days later, I uncovered the eyes, and examined them with a view to performing an iridectomy on the left eye. What was my surprise when I found that the nebulous condition had almost entirely disappeared in that eye, although it had been clouded over to such an extent as to prevent vision almost entirely for more than five years. The cornea appeared almost perfectly clear over the entire area, and iridectomy was unnecessary. On examining her vision a week later, I found: vision in the right eye, 6/18 (or 0, 3, 2) and ability to read Jaeger's test type no. 1; vision in the left eye, 6/9 (or 0, 6, 5).

COMMENT

As my observations were in harmony with those of five other surgeons who were present on both occasions, and who examined the cornea most carefully with a strong lens and also with the slit-lamp microscope, I cannot well have made any mistake concerning the appearance of the patient's eyes. I am at a loss to give a satisfactory explanation. The existence of a nebulous cornea during five years excludes the supposition of its spontaneous healing in almost as many days. Certainly, the removal of the adhesions in the right iris was immediately followed by a clearing up of the left cornea, which before the operation was the most opaque of the two. Whether I am justified in calling this a case of sympathetic keratitis remains for others better qualified for this work than I to decide. I give only the facts, and await for others to publish the right explanation.

EXFOLIATION OF THE MOST SUPERFICIAL LAMELLA OF THE ANTERIOR CAPSULE OF THE CRYSTALLINE LENS *

DANIEL B. KIRBY, M.D.
NEW YORK

Alling [1] reported seven cases of exfoliation of the lens capsule. I likewise observed seven cases of this condition at Bellevue Hospital. The appearance of the capsule of the lens and the conclusions to be drawn from the observations tallied with those of Dr. Alling. It is important to define the condition more accurately, however, as a separation and exfoliation of the most superficial lamella of the capsule of the lens.

It has been demonstrated that the lens capsule can be separated into layers by chemical treatment in the laboratory.[1] Clinically, separation and exfoliation occur in a certain small percentage of cases in elderly people. I have seen seven cases in seven years, and, as a routine measure, have examined the lenses of all elderly patients with the biomicroscope for early signs of cataract.

When exfoliation of the anterior capsule is present, the appearance is that of a roughened surface with light bluish-gray opaque flakes on the capsule, on the pupillary margin and, in some cases, on the anterior surface of the iris and the endothelial surface of the cornea. When the pupil is dilated, most of these cases give the impression that the play of the iris in contraction and dilatation has much to do with the denuding of the surface. Some degenerative process evidently preceded, and the rubbing of the iris produced the characteristic picture. There is usually a ring of tags of capsule adherent to the lens at the area of maximal contraction of the pupil, and outward from there in a number of cases extend frostlike patches which indicate that the areas between have been denuded by the uneven posterior surface of the iris. The appearance is not suggestive of the false membrane formation seen in various inflammatory states, but is definitely indicative of a degenerated and friable superficial opaque lamella that has come from the capsule of the lens.

---

* Submitted for publication, March 26, 1930.

* Read before the Eye Section, New York Academy of Medicine, Feb. 17, 1930.

* From the Department of Ophthalmology, College of Physicians and Surgeons, Columbia University. The cases reported were observed during the time the author was Research Fellow for the American Academy of Ophthalmology and Oto-Laryngology.

1. Alling, A. N.: Exfoliation of the Lens Capsule, Arch. Ophth. **56**:1 (Jan.) 1927.

The minute particles that are detached become adherent to the iris or to the cornea after circulating in the aqueous. The possibility of the rôle of these particles in the production of glaucoma by obstructing the spaces of Fontana in the drainage is easily seen.

OBSERVATIONS ON CASES

CASE 1.—M. G., a white woman, aged 60, showed circular exfoliation in both eyes. There were many flakes on the iris and a star-shaped cataract with a lamellar separation in the right eye.

CASE 2.—C. S., a white woman, aged 58, showed circular exfoliation at the pupillary margin in the right eye only. There was lamellar separation in both eyes.

CASE 3.—In J. F., a white man, aged 66, there were fine bluish-gray flakes on the pupillary margins. Fine flakes were seen on the anterior lens capsule. The right eye showed vacuoles and opaque suture lines. Trephining with iridectomy for glaucoma had been performed on the left eye.

CASE 4.—S. M., a white woman, aged 64, showed aphakia of the right eye, but capsule flakes still clung to the border of the iris. Marked exfoliation was seen in a disklike area of the left eye. There was lamellar separation.

CASE 5.—In W. G., a white man, aged 65, there was exfoliation with definite markings or iris on the lens. The right eye showed lamellar separation, and the left eye mature cortical cataract.

CASE 6.—J. M., a white man, aged 58, showed circular exfoliation. There was incipient cortical cataract in both eyes.

CASE 7.—In C. M., a white man, aged 60, there were frostlike changes in arrangement, which definitely indicated the denuding action of the iris. Definite chronic simple glaucoma with glaucoma atrophy was present. There was incipient cortical cataract with vacuoles and water-split sutures.

In all of these cases there was associated a senile cortical change in the lens. In two of them there was evidence of increased intra-ocular pressure. In none of them was a denuding of the posterior capsule observed. The condition appears essentially to be a degeneration of the anterior capsule of the lens. This is especially interesting in view of the fact that under the most trying conditions of inflammation, pressure, trauma, etc., the glass membrane capsule of the lens maintains its transparency. Sections of even markedly degenerated eyes show that the capsule remains transparent.

Case 3 is especially interesting, because it offers an opportunity to distinguish between these capsular flakes which lie on the pupillary margin and a possible false membrane. The appearance in this case was distinctive (see illustration). Very little of the exfoliated material clung to the capsule. Glaucoma was present in the left eye for which the patient had had a trephine and peripheral iridectomy. In the peripheral iridectomy coloboma above, one may observe in the illustration the typical appearance of granular and flaky, frostlike exfoliation of the capsule

Drawing showing the peculiar frostlike appearance of the capsule of the lens in the peripheral iridectomy coloboma, and the exfoliated capsular particles adherent to the pupillary margin.

with denuded areas that indicate definitely the action of the iris on the opaque, friable material.

In a recent addition to his contributions on this subject, Vogt [2] called the condition "Linsenkapselglaukom." He found the curious lesions to be not so rare as supposed, as he had now observed forty-five cases. The average age is between 60 and 80 years. He emphasized the case of a man, aged 80, who had been examined with the aid of the microscope one year before his death. The condition of exfoliation of the superficial lamella of the capsule of the lens similar to the stripping off of the zonular lamella was present. The intra-ocular tension was found to be high normal. The papilla appeared unchanged. Fortunately, it was possible to obtain the specimens at autopsy for histologic examinations. Interesting photomicrographs were reproduced in the article. They showed definitely a separation of the superficial lamella from the capsule. This was the first time that this condition had been examined histologically.

In a series of 185 cases of chronic glaucoma observed by Vogt in four years, there were thirteen cases apparently due to exfoliation of the capsule of the lens. In a total of forty-five cases of exfoliation of the capsule of the lens that Vogt observed, thirty-four patients or 75 per cent had glaucoma. It is therefore an important form of glaucoma, really secondary to the blocking of the iris angle by the capsular particles. Vogt found the operative prognosis poorer than in ordinary chronic simple glaucoma.

CONCLUSION

Clinically, a small number of cases show exfoliation of the most superficial lamella of the anterior capsule of the crystalline lens.

2. Vogt, A.: Neue Fälle von Linsenkapselglaukom, Klin. Monatsbl. f. Augenh. **84**:1 (Jan.) 1930.

Ophthalmologic Review

CHEMICAL AND IMMUNOLOGIC RESEARCHES ON LENS PROTEIN

ALAN C. WOODS, M.D.
BALTIMORE

The chief investigations on the crystalline lens fall into three general groups: (1) the chemical researches, (2) researches which concern themselves with the action of radiant energy on the lens and (3) immunologic researches.

The earliest chemical analyses of the crystalline lens are those of Laptschinsky [1] in 1876. They were followed by the early fundamental researches of Morner in 1894,[2] which were later confirmed by Jess [3] with more accurate analyses. These authors first demonstrated that lens protein had two different crystallins, which they called alpha and beta crystallins; and also an insoluble residue which they termed "albuminoid." Lens protein as a whole contains between 16 and 17 per cent nitrogen. The sulphur content varies from 0.5 to 1 per cent in alpha crystallin and from 0.1 to 0.3 per cent in beta crystallin. These alpha and beta crystallins contain the usual amino-acids in greater or lesser quantity. The most interesting of these amino-acids is cysteine, which gave some information concerning the auto-oxidation system of the lens. Cysteine is an SH-containing amino-acid which gives a positive sodium nitroprusside reaction. It is rapidly oxidized in vitro into an SS-containing compound called cystine, which does not give the sodium nitroprusside reaction. The sodium nitroprusside reaction is considered the index to an active metabolism. The SH cysteine was found in large quantities in beta crystallin, but in cataractous lenses it was totally absent, only the SS cystine being found. The sodium nitro-

1. Laptschinsky: Ein Beitrag zur Chemie des Linsengewebes, Pflüger's Arch. f. d. ges. Physiol. **13**:631, 1876.

2. Morner, Carl T.: Untersuchung der Proteinsubstanzen in den lichtbrechenden Medien des Auges, Ztschr. f. physiol. Chem. **18**:213, 1894; Untersuchung der Proteinsubstanzen in den lichtbrechenden Medien des Auges, ibid. **18**:233, 1894; Eine wohlcharakterisierte orgainische Schwefelverbindung, erhalten aus Proteinstoffen bei Behandlung derselben mit Salpetersaure, ibid. **93**:175, 1914-1915.

3. Jess, A.: The Histidine, Arginine and Lysine Content of Lens Protein, Ztschr. f. physiol. Chem. **122**:160, 1922; Am. Chem. Soc., Jan.-May, 1923, vol. 171; Albumins in Investigation of Cataract, Graefe Arch. **109**:463, 1922; Monamino Acids in Lens of the Eye, Ztschr. f. physiol. Chem. **110**:266, 1920; Am. Chem. Soc., June-Oct., 1921, vol. 152.

prusside reaction was practically absent in the cataractous lens, as has been shown by the researches of Reis.[4]

A number of other chemists, deRey-Pailhade,[5] and others, became interested in the auto-oxidation of sulphur which occurred in animal tissues, and these researches finally culminated in the brilliant work of Goldschmidt.[6] Goldschmidt demonstrated the fact that the human lens contained an actual auto-oxidation system with a definite ability to take up and utilize oxygen, and thus transform the SH cysteine into an SS cystine. Goldschmidt further demonstrated that this was a reversible reaction, thus enabling the lens to carry on a metabolism involving little wear and tear. He showed that there were two definite factors in this auto-oxidation system: (1) a dialyzable constituent known as glutathione, and (2) a thermostable constituent. The researches of Adams,[7] under the Glass Blowers Cataract Investigation Commission in England, later identified this thermostable constituent with beta crystallin.

Goldschmidt's further researches show that in advancing years the electrolyte content of the lens greatly increases, calcium increasing 15 per cent and phosphor salts 20 per cent. The importance of this observation will become evident subsequently.

Other important researches on the chemistry of the lens are those concerned with the lipoid and myelin content of the lens. Lipoids have been demonstrated and their content estimated by a number of observers, notably, Valentin,[8] Goldschmidt, Hoffmann[9] and others. In 1914, Hoffmann demonstrated myelin figures throughout cataractous lenses, and he believed that this was a specific symptom of the cataractous process. He finally concluded that the formation of cataract was due to a ferment action in the protein. The source of these ferments he could not prove to lie solely in the lens. He believed that various different potent principles in ferments might account for the various forms of cataract.

---

4. Reis, Wiktor: Ueber die Cysteinreaktion der normalen und pathologisch veränderten Linsen, Arch. f. Ophth. **80**:588, 1912.

5. DeRey-Pailhade, J.: Chemie biologique—sur un corps d' origine organique hydrogenant le soufre a froid, Compt. rend. Acad. d. sc. **106**:1683, 1888.

6. Goldschmidt, M.: Ueber physiologisch chemische Altersveränderungen des Auges, Klin. Monatsbl. f. Augenh. **72**:777, 1924; The Lipoids of the Lens, Biochem. Ztschr. **127**:210, 1922; Am. Chem. Soc., Jan.-May, 1922, vol. 161.

7. Adams, D. R.: Investigation on Crystallin Lens, Roy. Soc. London, Ser. 6, **98**:244, 1925

8. Valentin, Frank: Fat-Like Substance in the Lens of the Horse Eye, Ztschr. f. physiol. Chem. **105**:33, 1919; Am. Chem. Soc., Nov.-Dec., 1919, vol. 133.

9. Hoffmann, M.: The Cataractous Degenerative Process of the Lens and Its Production in the Reagent Glass, München. med. Wchnschr. **61**:584, 1914; **60**:741, 1913.

Jess apparently agreed with this theory of Hoffmann's, but Goldschmidt, whose excellent work on the auto-oxidation system has already been mentioned, further showed that this auto-oxidation system is sensitive to changes in the hydrogen ion concentration, the auto-oxidation system apparently ceasing to function in the human lens when the p_H becomes more acid than 7. He advanced the theory that a change toward the acid side produced a disturbance of the power of the lens to utilize oxygen, and this was concerned in the precipitation of the lens protein. Against this view of Goldschmidt's stand the researches of Burdon-Cooper,[10] who found that in cases of cataract the aqueous was generally alkaline in its reaction, and Hayano[11] showed that while the normal lens has a definite power to neutralize alkali, this power grows less and less with advancing age, and in a lens with cataract is greatly below normal, the swing thus being to the alkaline rather than the acid side.

Adams believed with Goldschmidt that a disturbance in the auto-oxidation system was concerned in the production of cataract. She suggested that disturbance in auto-oxidation in cataract was due to the destruction of the glutathione, and that this destruction was brought about by radiant energy.

THE EFFECT OF RADIANT ENERGY ON THE PROTEIN OF THE LENS

In 1907, Dreyer and Hansen[12] showed that ultraviolet light could coagulate protein. It has previously been shown by a large number of observers, notably, Brucke,[13] that the media of an eye, the aqueous, vitreous, cornea, and especially the lens, have the power to absorb ultraviolet light.

Schanz and Stockhausen[14] have shown that the rays from 350 to 300$\mu\mu$ penetrate the eye but are absorbed by the lens, that rays of 300$\mu\mu$ and less are absorbed chiefly by the cornea, and that rays from 760 to 400$\mu\mu$ pass directly through to the retina. Many observers, knowing that ultraviolet light could produce coagulation of certain proteins, and that light of this wave length was largely absorbed by the

10. Burdon-Cooper, J.: Aetiology of Cataract, Brit. J. Ophth. **6**:385, 1922.

11. Hayano, R.: Power of the Lens of the Eye to Neutralize Alkaline Solutions, Tokyo Igakukai Zasshi **31**:1, 1917; Japan M. Lit. **3**:60, 1918; Am. Chem. Soc. **131**:469 (Jan.-May) 1919.

12. Dreyer, Georges, and Hansen, Olav: Photochemie—Sur la coagulation des albumines par l' action de la lumiere ultra-violette et due radium, Compt. rend. Acad. d. sc. **145**:234, 1907.

13. Brucke, Ernst: Ueber das Verhalten der optischen Medien des Auges gegen Licht- und Warmestrahlen, Muller's Arch. f. Anat., 1845, p. 262.

14. Schanz, F., and Stockhausen, C.: Zur Aetiologie des Glasmacherstars, Arch. f. Ophth. **73**:553, 1910.

lens, investigated the problem of whether this absorption of ultraviolet light by the lens might be in some way associated with the coagulation of protein recognized clinically as cataract.

In 1912, Chalupecky [15] exposed normal hog lens to ultraviolet light, and after three hours of such exposure he found changes which he believed were analogous to those found in senile cataract. In a later experiment he exposed the eyes of living guinea-pigs to the action of a quartz lamp for seven hours, and in several of these guinea-pigs likewise found definite changes in the crystalline lens. Chalupecky's experiments were to a great extent confirmed by later experiments by Schanz,[16] but Jess and Koschella [17] were unable to confirm them. Trümpy [18] likewise was unable to confirm these observations, but was greatly impressed by the inflammatory changes in the anterior ocular segment which followed irradiation with ultraviolet light. Van der Hoeve,[19] in 1926, then advanced the theory that ultraviolet light was dispersed by the lens and so caused degeneration of the ciliary process, that this disease of the ciliary process interfered with the nourishment of the lens and that the resulting disturbance in the nutrition in the lens was the chief factor in the etiology of senile cataract.

The action of ultraviolet light on the lens was investigated in this country at some length by Burge.[20] He made many remarkable observations. He found, first, that thirty hours' irradiation with ultraviolet light produced no precipitation in normal lens protein, but when this radiated protein was later exposed to 0.1 per cent concentration of calcium chloride, the radiated protein became opaque. Further experiments showed that while lens protein itself was not precipitated by the action of ultraviolet light alone, it was precipitated by ultraviolet light

15. Chalupecky, H.: Wien. med. Wchnschr. **64**:1515, 1913 (Year Book, 1914, p. 235); Influence of Ultra-violet Rays on Crystallin Lens, Wien. klin. Wchnschr. **63**:1902 and 1986, 1912 (Year Book, 1913, vol. 10).

16. Schanz, F.: Die Wirkungen des Lichtes auf die lebende Substanz, Pflüger's Arch. f. d. ges. Physiol. **161**:384, 1915; Biochem. Ztschr. **71**:406, 1915; Pfluger's Arch. f. d. ges. Physiol. **164**:445, 1916; Biochemical Action of Light, ibid. **170**:646, 1918; Am. Chem. Soc., June-Oct., 1919, vol. 132.

17. Jess, A., and Koschella, A.: Influence of Ultra-violet Light on Cystein Reaction of Lens, Graefe Arch. **11**:370, 1923.

18. Trümpy, E.: Violet and Ultra-violet Light 435.9-314 M.U. do not Cause Cataract, but Inflammation of Conjunctiva is Caused by Rays 314-253.6 M.U., Arch. f. Ophth. **115**:495, 1925.

19. Van der Hoeve, V.: Strahlen und Auge, Arch. f. Ophth. **116**:245, 1926.

20. Burge, W. E.: Arch. Ophth. **38**:447, 1909; The Action of Ultra-violet Radiation in Killing Living Cells such as Bacteria, Am. J. Physiol. **43**:429, 1917; The Mode of Action of Ultra-violet Radiation on Injured Cells with Special Reference to Those Constituting the Eye, ibid. **39**:335, 1915; The Production of Cataract, Arch. Ophth. **47**:12, 1918.

in the presence of an excess of electrolytes, notably calcium and silicon. One of Burge's most interesting experiments was the production of cataracts in living fish. He kept fish in water which contained calcium chloride in 0.8 per cent concentration, and exposed the eyes of these fish to ultraviolet light. Such fish developed definite cataracts, while fish exposed to light alone, without calcium in the water, did not develop cataract. Burge further found that the calcium content of the normal lens is 0.08 per cent, and that in the cataractous lens it is increased to 15 per cent. He therefore believed that two factors were necessary in the production of cataract: (1) absorption of ultraviolet light and (2) an excess of electrolytes, notably calcium.

The exact histologic changes produced by the abiotic action of ultraviolet light on the lens was first studied by Hess [21] in 1907, later by Martin,[22] Verhoeff and Bell,[23] and finally by Duke-Elder.[24]

Hess described the so-called "epithelial wall." This comes on about twenty hours after irradiation with ultraviolet light and is a large, abrupt swelling of the epithelial cells from four to six layers deep around the pupillary border of the lens, bulging the lens capsule on one side and indenting the lens substance on the other. The nuclei of these cells take an eosinophilic stain, and mitotic figures are completely absent. The exact changes occurring in the lens substance are swelling and blurring of the lens fibers, which lose their orderly arrangement, and a loss in the staining properties. This change occurs most markedly in the lens substance immediately beneath the capsular epithelium.

Duke-Elder regarded the changes in the lens substance of a physical chemical nature due to the effect on the auto-oxidation system by the ultraviolet light.

Meanwhile, while Chalupecky, Schanz, Burge and others were concentrating their efforts on the effect of ultraviolet light on the precipitation of lens protein, other investigators were studying the effects of other forms of radiant energy, notably the infra-red rays, on the protein of the lens. Sir William Crooks,[25] in 1914, first advanced the theory that the infra-red rays were responsible for glassblowers' cata-

21. Hess, Von C.: Versuche über die Einwirkung Ultravioletten Lichtes auf die Linse, Arch. f. Augenh. **57**:185, 1907.

22. Martin, E. K.: The Effects of Ultra-violet Rays upon the Eye, Proc. Roy. Soc. London **85**:319, 1912.

23. Verhoeff, F. H., and Bell, Louis: The Pathological Effects of Radiant Energy on the Eye, Proc. Am. Acad. Arts & Sc., July, 1916, vol. 51.

24. Duke-Elder, W. S., and Duke-Elder, P. M.: A Histological Study on the Action of Short-Waved Light upon the Eye, with a Note on "Inclusion Bodies," Brit. J. Ophth. **13**:1 (Jan.) 1929.

25. Crooks, Sir W.: Philosophical Transactions, Roy. Soc. London, 1914, A, Tr. p. 500.

ract. Meyhofer,[26] Birch-Hirschfeld[27] and others agreed with this idea. Other observers criticized this conclusion for the reason that the primary change in glassblowers' cataract occurred in the posterior pole of the lens; whereas the anterior portions would normally be the part of the lens on which heat would exert its maximum effect. Hartridge and Hill[28] stated the belief that infra-red rays produced changes in the lens by affecting the secretion of the aqueous. They demonstrated that while the infra-red rays pass into the eye unchecked and a large portion reaches the retina, a great portion of the infra-red rays is absorbed by the iris. Voght[29] confirmed the observation that heat waves reached the retina, and believed that in the glassblowers' cataract both the lens and the retinal damage were due to such waves. Parsons[30] later suggested that the heat absorbed by the iris affected the secretion of the aqueous with secondary changes in the nutrition of the lens.

Summarizing the chief investigations on the action of radiant energy on the lens, it would appear definitely that ultraviolet light has the ability to produce coagulation of lens protein in the presence of an excess of electrolytes, and may also cause changes in the lens by interfering with its nourishment by damaging the ciliary process. The evidence in favor of the action of infra-red rays on the lens is somewhat less convincing. It is clear, however, that the infra-red rays are absorbed to some extent by the iris, and that they may produce definite changes in the iris, the ciliary process and the concentration of aqueous. Such changes may have a definitely deleterious effect on the nourishment of the lens.

IMMUNOLOGIC PROPERTIES OF LENS

The third phase of investigation of lens protein has to do with the remarkable immunologic properties of the lens. These properties were first discovered by Uhlenhuth[31] in 1903. He showed that the lens was organ-specific in its antigenic properties, and apparently not species-

26. Meyhofer: Zur Aetiologie des grauen Starrs jugendliches Katarakten bei Glasmachern, Klin. Monatsbl. f. Augenh. **24**:49, 1886.

27. Birch-Hirschfeld, A.: Die Wirkung der Ultravioletten Strahlen auf des Auge, Arch. f. Ophth. **58**:469, 1904.

28. Hartridge, H., and Hill, A. V.: The Transmission of Infra-red Rays by the Media of the Eye and the Transmission of Radiant Energy by Crookes and Other Glasses, Proc. Roy. Soc. London **89**:58, 1917.

29. Voght, A.: Experimentelle Untersuchungen über die Durchlassigkeit der durschsichtigen Medien des Auges für das Ultrarot kunsthscher Lichtquellen, Arch. f. Ophth. **81**:155, 1912.

30. Parsons, J. H.: Affections of the Eye Produced by Undue Exposure to Light, Seventeenth International Congress of Medicine, 1913, sect. 9, p. 193.

31. Uhlenhuth, P.: Zur Lehre von der Unterscheidung verschiedener Eiweissarten mit Helfe spezifischer Sera, Festschrift zum sechsigsten Geburtstage von Robert Koch, Jena, 1903; Arch. Ophth. **53**:342, 1924.

specific. These same properties have been confirmed time and again by numerous observers, notably Hektoen.[32] Hektoen further found that this same property of organ-specificity held true in both A and B fractions of the lens. However, he was unable to separate these fractions sharply in the precipitogenic sense.

Woods and Burky [33] further investigated the chemical and immunologic properties of the lens crystallins. They finally prepared the alpha and beta lens crystallins in serologically pure form, and discovered a third fraction in lens protein—the gamma crystallin. These authors precipitated the α crystallin from the whole lens mixture by the addition of tenth-normal acetic acid, the α crystallin being precipitated while the β crystallin remains in solution. A sharp separation of these two crystallins was made by precipitating the different crystallins at their iso-electric points, the iso-electric point of protein being the point at which the protein is neither acid nor alkaline, and this is the point of minimum solubility. It was thus found that the alpha fraction could be precipitated by adding tenth-normal acetic acid to a point somewhat beyond p_H 4.8, while the iso-electric point for the beta fraction was in the neighborhood of p_H 6. The α crystallin is purified by further precipitation to p_H 4.8, and the β crystallin is purified by repeatedly dializing out the acid and again precipitating the remaining traces of the α crystallin. A short cut for the preparation of the β crystallin was later devised, which is of no importance in the present discussion. The so-called "albuminoid" portion of the lens described by former observers was identified immunologically with the α crystallin, and it appears probable that Morner was mistaken in his first assumption that this residue was "albuminoid." The α crystallin apparently belongs to the old class of serum globulins which contain two portions, a soluble pseudoglobulin, which is apparently the α crystallin as it is known, and an insoluble portion, or a euglobulin, which was formerly mistaken for an albuminoid. Puzzling reactions were noted in the behavior of the β crystallin. The investigation of this reaction led to the isolation of an entirely separate component in the original β crystallin, which was called gamma crystallin. This is definitely an albumin and apparently represents the entire albumin content of the lens. It is peculiar that it does not act as an antigen when injected into animals in pure form but is able to act as an antigen in a test tube. This is, however, a common property of albumins. The

32. Hektoen, L.: The Specific Precipitin Reaction of the Lens, J. A. M. A. **77**:32 (July 2) 1921; Immune Reactions of the Lens, Am. J. Ophth. **6**:278, 1923; The Specific Precipitin Reaction of the Normal and Cataractous Lens, J. Infect. Dis. **31**:77, 1922.

33. Woods, Alan C., and Burky, Earl L.: Lens Protein—The Isolation of a Third (Gamma) Crystallin, Arch. Ophth. **57**:464 (Sept.) 1928.

lens protein, therefore, may be considered to be made up of the following separate and distinct entities, the α and β crystallins, which are pseudoglobulins, a euglobulin, which is immunologically identical with the alpha crystallin, and the gamma crystallin, which is an albumin.

Roemer and Gebb [34] believed that this immunologic specificity of lens protein was concerned in the production of cataract. Roemer's investigations were not conclusive. He showed that the capsule of the lens was permeable to certain toxins to which the lens was apparently susceptible. He claimed to demonstrate in the blood serum of a young diabetic patient precipitins which were specific for lens protein. This observation has not been confirmed, however, by other observers. Roemer [35] further attempted to treat patients with cataract by administering lens protein by mouth. His efforts were unsuccessful.

The later experiments of Guyer and Smith [36] in this country aroused a great deal of interest. Guyer and Smith found that pregnant rabbits injected with antilens serum gave birth to offspring, a number of which showed ocular defects, chiefly centered about the lens. Other researches from their laboratory, however, have indicated that this was apparently not due to any specific immunologic reaction of the lens antibodies, but rather to an imperfect closure of the primary fetal cleft, the primary defects lying in the neuro-ectoderm and not in the surface ectoderm, which subsequently becomes the crystalline lens.

All theories that suppose the peculiar immunologic properties of the lens are concerned with the causation of senile cataract pivot around the supposition that in some way these peculiar immunologic properties can be exerted in the same subject, the "horror autotoxicus" by Erlich. With the exception of the single observation of Roemer and Gebb, there have been no demonstrations of any immunologic change in the organism produced by lens protein in cases of senile cataract. The work of Verhoeff and Lemoine [37] on endophthalmitis-phaco-anaphylactica is advisedly excepted, for these authors are dealing with a radically different problem. Blood serum of cataractous subjects has been investi-

34. Roemer, P., and Gebb, H.: Untersuchungen über des biologische Verhalten des Blutserums zum Linseneiweiss bei Kataract, Arch. f. Augenh. **77**:316, 1914.

35. Roemer, P.: Die Pathogenese der Cataracts senilis vom Standpunkt der Serumforschung (Pts. 1 and 2), Arch. f. Ophth. **60**:175, 1905; Stoffwechsel der Linse und Giftwirkungen auf Dieselbe, Ber. d. Ophth. Gesell., 1906, p. 33; Die Pathogenese der Cataracts senilis vom Standpunkt der Serumforschung (Pts. 3, 4, 5 and 6), Arch. f. Augenh. **56**:150 (supp.), 1907; Specifische Therapie des beginnenden Altersstares, Ber. d. Ophth. Gesell., 1908, p. 35.

36. Guyer, M. F., and Smith, E. A.: Studies on Cytolysins: Some Prenatal Effects of Lens Antibodies, J. Exper. Zool. **26**:65, 1918; Studies on Cytolysins: Transmission of Induced Eye Defects, ibid. **31**:171, 1920.

37. Verhoeff, F. H., and Lemoine, A. N.: Endophthalmitis Phacoanaphylactica, Internat. Cong. Ophth., Washington, D. C., 1922, p. 234.

gated in Aberhelden reaction, precipitin reaction, complement-fixation reactions and the refraction index. In 1924, a French observer, Gourfein-Welt,[38] reported a slight change in the refraction index of cataractous serums investigated under rather remarkable conditions. This work, however, not only was unconvincing, but was totally unsuggestive.

Experimentally this question of the production of auto-iso-antibodies was investigated by Hektoen and Schulhof.[39] While Hektoen and Schulhof were unable to produce specific antibodies in rabbits by injection of rabbit lens protein alone, they found that the rabbit lens protein would produce specific antibodies if the antibody mechanism has previously been stimulated by the injection of foreign lens protein. Further work on this point has been informally reported by Woods and Burky at society meetings but has not yet been published.

Even if it can be demonstrated that general auto-iso-immunologic reactions can be stimulated by lens protein, it is by no means clear just how such reactions may effect the tissues of the eye. In 1903, Roemer demonstrated that antibodies circulating in the blood stream were not present in the aqueous of the eye under normal conditions, but if a paracentesis was done and the old aqueous drained off, the new aqueous secreted contained these specific antibodies. In 1912, E. K. Martin confirmed this observation and further showed that the irradiation of the eye with ultraviolet light caused hemolysins present in the blood stream to appear spontaneously in the aqueous.

If one summarizes the situation, one finds that the following chief advances have been made in the knowledge of the lens. The crystalline lens contains an auto-oxidization system which is dependent on two elements, a thermostable residue and an oxidizing substance known as glutathione. The thermostable constituent is apparently contained in the beta crystallin. This auto-oxidization system is destroyed in cataractous lenses.

There is definite evidence that radiant energy has a coagulating effect on the protein of the lens. As far as the ultraviolet rays are concerned, this precipitation of protein is apparently active only when there is an excess of electrolytes present, and it has been shown that in old age the electrolyte content of the lens greatly increases. It is also known that radiant energy has a definitely deleterious effect on the anterior structures of the eye, and that it is possible that changes in the lens may follow damage to its nutrition secondary to changes in the ciliary process

38. Gourfein-Welt, L.: Le serum du sang des cataracteaux differe et il de celin des non-cataracteux, Rev. gén. d'opht. **38**:147, 1924.

39. Hektoen, L., and Schulhof, K.: Further Observations on Lens Precipitins: Antigenic Properties of A- and B-Crystallins, J. Infect. Dis. **34**:433, 1924; Am. Chem. Soc., Jan.-May, 1925, vol. 191.

caused by radiant energy. There is also evidence that radiant energy itself has a destructive action on the glutathione content of the lens. There is some evidence that the visible spectrum and infra-red rays have a similar destructive effect on the lens and anterior ocular segment, and there is a possibility that these changes may produce secondary disturbances in the lens.

Finally, from the immunologic standpoint, lens protein is a most unusual and complex substance. It contains three fractions which differ in the specific immunologic responses evoked, and differ in such reactions from all other homologous body protein, but there is as yet no evidence to indicate that these peculiar properties are in any way related to the pathogenesis of senile cataract.

Correspondence

PRELIMINARY NOTE ON THE FORM OF NORMAL HUMAN VISUAL CELLS

To the Editor:—A year ago we secured a normal human eye by operation, and prepared it for a study of the visual cells. (It was this retina that furnished the material for our paper on Ectopic Cone Nuclei, ARCH. OPHTH. 3:736 [June] 1930.) The situation found was so wholly at variance with that represented in the classic and much-copied figures of Greeff (in Graefe-Saemisch: Handbuch der Gesamten Augenheilkunde, ed. 2, Leipzig, Engelmann, 1900, parts 20, 21 and 22; especially fig. 36) that it has seemed worth while to treat it briefly here. More rigid conclusions, with complete descriptions and figures, must await our securing additional material, which, of course, may not come to hand for some time.

The eye in question was taken from a white American, aged 61. The family history was unimportant, and the patient had 6/5 vision with correction in the enucleated eye; the color vision was normal. Orbital carcinoma necessitated the enucleation and subsequent exenteration.

Very few minutes elapsed between the stoppage of circulation and the exposure of the retina to fixatives. The dorsal and ventral segments were fixed in Flemming's and Perenyi's fluids, respectively, neither of which was as satisfactory as the Kolmer's fluid which was used on the central zone. (Kolmer's fluid: saturated potassium bichromate, 4 parts; a diluted solution of formaldehyde U.S.P. (1:10), 4 parts; glacial acetic acid, 1 part; mix fresh; fix twenty-four hours.) The material was embedded by the hot nitrocellulose method and sectioned at 10 microns; several stains were used.

The most striking disparity between our observations and those of Greeff and others is in the length of the cone outer segment. There is every indication that the living cone outer segments, in all parts of the retina, are nearly cylindric and reach the pigment epithelium. We believe that the situation in man is practically identical with that in the Macaque as shown by the remarkable photomicrograph of Garten (in Graefe-Saemisch: Handbuch der Gesamten Augenheilkunde, ed. 2, 1907, parts 119-121, plate 2, fig. 31). The excellency of Garten's preservation is probably unattainable on human material, as he injected the fixative intracardially.

We are not acquainted with a text or separate paper that carries an illustration of the human visual cells even closely approximating the condition that we find; the nearest approach is perhaps that in Stöhr's histology in its various English editions.

GORDON L. WALLS, M.A., and ARTHUR M. CULLER, M.D.,
Ann Arbor, Mich.

News and Notes

EDITED BY DR. JOHN HERBERT WAITE

GENERAL NEWS

Colorado Congress of Ophthalmology and Oto-Laryngology

The program of the congress, which will be held on Aug. 1-2, 1930, is announced. The papers on ophthalmology are:

1. Dr. Roderick O'Connor, Oakland, Calif.: Ocular Muscle Action Under Sherrington's Law; Its Influence on Operative Results.

2. Dr. Beulah Cushman, Chicago: Tuberculous Iridocyclitis.

3. Dr. A. M. Lemoine, Kansas City, Mo.: Subject to be announced later.

4. Dr. J. S. Friedenwald, Baltimore: Pigmentary Degeneration of the Retina in Late Neurosyphilis.

5. Dr. H. G. Merrill, Provo, Utah: Uveitis Associated with Parotitis.

6. Dr. A. B. Bruner, Cleveland: Some Clinical Aspects of Acute Glaucoma.

7. Dr. Edward Jackson, Denver: The Control of Myopia.

The following are the papers on otolaryngology:

8. Dr. L. W. Dean, St. Louis: The Relationship Between Otolaryngology and Internal Medicine and Pediatrics.

9. Dr. A. M. Painter, Kansas City, Mo.: The Tonsil Question.

10. Dr. T. S. Blakesley, Kansas City, Mo.: An Operation for Chronic Dacryocystitis.

11. Dr. B. L. Myers, Kansas City, Mo.: Subject to be announced later.

12. Dr. J. F. Barnhill, Indianapolis: Are Otolaryngologists Operating More than Necessary?

13. Dr. Lewis Fisher, Philadelphia: A Proved Case of Brain Abscess Complicating Middle Ear Suppuration; Methods of Diagnosis.

14. Dr. L. W. Oakes, Provo, Utah: Sphenoidal Sinus Syndrome.

SOCIETY NEWS

North Dakota Academy of Ophthalmology and Oto-Laryngology.—The twelfth annual meeting of the North Dakota Academy of Ophthalmology and Oto-Laryngology was held under the presidency of Dr. George M. Constans at Bismarck on May 27. Illustrated addresses were presented by Dr. W. L. Benedict of Rochester, Minn., and Dr. A. D. McCannel of Minot, N. D. Dr. Benedict spoke on "Tumors and Pseudo-Tumors of the Orbit." Dr. McCannel's subject was "Bronchoscopy and Esophagoscopy." Dr. H. B. Beeson, of Grand Forks, was elected president for the coming year.

Course in Physiologic Optics.—Dr. Edward Jackson gave a course in Physiologic Optics to a class of thirty-five ophthalmologists in May in Detroit.

New York State Medical Society.—Dr. Conrad Berens was elected chairman of the Section on Eye, Ear, Nose and Throat of the New York State Medical Society. At the Rochester meeting on June 4, Dr. Harry Gradle, of Chicago, and Dr. Luther Peter, of Philadelphia, were the invited speakers of the section. The ophthalmologists and otolaryngologists attending the meeting were the guests of the Rochester Eye, Ear, Nose and Throat Club at two luncheons at the University Club of Rochester.

State Medical Association of Texas.—Dr. J. O. McReynolds has been made president of the association. A banquet was tendered him by the Dallas Chamber of Commerce on June 14.

Obituary

ARCHIBALD LYLE MACLEISH, M.D.
1854-1930

Dr. Archibald Lyle Macleish died on May 20, 1930. He was born in Dunlop, Scotland, seventy-six years ago. Early in life he showed the industry and the passion for exactness that characterized his whole life and made him, for a generation, the outstanding ophthalmologist and a greatly respected citizen of southern California.

He attended the University of Edinburgh, supported by his own efforts, winning four scholarships, first class honors in the classics and second class honors in mathematics. There he was awarded the degrees of M.A., M.B., C.M. and M.D., and he became president of the Royal Medical Society of Edinburgh.

In 1881, he became Physician to the Presbyterian Mission in Amoy, China, where he had to care for patients with any disease, including diseases of the eye. Here he performed his first 100 operations for cataract without anesthesia.

In 1894, he came to America and settled in Los Angeles; he had no money but a large family, and his wife was fatally ill. At this time the strength of character that made him a distinguished man manifested itself to the full. He had determined to be an ophthalmologist; he was told by medical friends not only that was there no demand for such a person, but that he would starve. This proved to be nearly correct; his gross income for the first year was $50. The temptation to go back into general practice and surgery must have been tremendous. But characteristically, he made no compromises with his plan, nor did he allow himself the least infraction of his strict code of professional ethics, at a time when the code was far from oppressive. It was a clear refutation of the not uncommon belief that financial success demands a judicious amount of chicanery.

This sternness of character led him to an unyielding condemnation of medical men whom he thought incompetent or indecent in their professional life; tolerance is not always a virtue. On the other hand, more than one ophthalmologist, newly settled in a strange city, owed his flying start to the patients sent him by Dr. Macleish and to his guidance and sponsorship.

Dr. Macleish was a member of numerous professional societies, including the American Ophthalmological Society and the Royal Medical Society of Edinburgh.

CARL FISHER.

Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

Conjunctiva

TREATMENT OF ACUTE PURULENT OPHTHALMIA OF GONOCOCCAL ORIGIN. R. P. WILSON, Giza Mem. Hosp., Cairo, 3d Ann. Rep., 1928, p. 60.

It was pointed out that in Egypt the principal cause of blindness is undoubtedly gonococcal ophthalmia and not trachoma. The usual treatment is to wash the eyes with perchloride of mercury, 1 : 5,000, and afterward to paint the conjunctiva with silver nitrate, 2 per cent. For the remainder of the morning, the mother bathes the eyes of the child with a weak solution of potassium permanganate. For the past year, special methods have been employed. Injections of milk were used on eight patients. No cases developed corneal complications. The severe cases responded as well as the milder ones. All discharge and swelling disappeared within an average of three days. Nine patients were treated with antidiphtheritic serum. The dosage was 8 cc. of serum, from one to seven injections being made. All discharge and swelling disappeared within an average of six and six-tenths days.

Thirteen patients were treated by injections of S. V. M. 36 (the symmetrical area of meta-benzoyl, meta-amino-naphthol, 3-6, and sodium sulphonate). The average dose was 0.01 Gm. The number of injections was from one to five. All discharge and swelling disappeared within an average of six and four-tenths days.

When milk was used, the results were uniform, with strikingly rapid disappearance of the symptoms. The time required for a cure was shorter than in any case by any other method. In all special methods, the usual routine local treatment was used. The conclusion was drawn that for routine treatment, except in case of milk therapy, no real advantage is gained by any of the aforementioned special methods.

W. ZENTMAYER.

TRACHOMA IN CYRENAICA IN RECENT YEARS. G. RUSSO DI GIUNTA, Ann. di ottal. e clin. ocul. **57**: 874 (Oct.-Dec.) 1929.

According to statistics of the author, director of the eye clinic at Bengasi, trachoma among the population of Cyrenaica has decreased in frequency from 37 per cent in 1925 to 13 per cent in 1928. It is still responsible for over half the cases seen in the clinic (57.06 per cent in 1925; 54.10 per cent in 1928). Trachoma occurs among the negro population, but usually in a mild form, and in a low percentage, the Jewish race being most frequently affected. Infection usually occurs in the early years of life. No cases of acute trachoma were seen, but many of Koch-Weeks infection superimposed on trachoma, which is responsible for the severest complications. Unilateral trachoma was seen only in classes having a relatively high standard of hygiene. In the schools, the incidence of trachoma is about that of the population

as a whole, decreasing appreciably in the higher classes, which is evidence against infection occurring in the schools themselves. Measures taken against the disease include examination of all students' eyes, compulsory treatment of those found to be affected, and their isolation, when possible, in a special school.

S. R. GIFFORD.

PLASMOMA OF THE CONJUNCTIVA AND TRACHOMA. F. PAPOLCZY, Klin. Monatsbl. f. Augenh. **83:** 788 (Dec.) 1929.

The author operated for plasmoma of the conjunctiva, as described by Pascheff in 1908, in five patients, all of them men, whose ages ranged between 19 and 38. Four of them had suffered from trachoma previously. The growths were noticed for periods varying from two months to eight years.

Plasmoma is identical with plasmozytoma, and is related to plasma cell conjunctivitis. Histologic examination proved the conjunctival epithelium to be intact. The tumors themselves consisted chiefly of plasma cells, interspersed with some connective tissue; mast cells and lymphocytes were found, but no giant cells, as reported by Rados and Pascheff. The plasma cells did not seem to originate from cells of the adventitia of the vessels. In one case, hyaline degeneration, which involves the connective tissue in some instances, had destroyed the plasma cells leaving only the peripheral cell layers intact; this process may involve the walls of the vessels. Amyloid degeneration occurred. These tumors are not malignant, nor do they cause infiltration of their surroundings. It is sufficient, therefore, to remove only those portions of the tumor which interfere with the motion of the lids.

Papolczy is of the opinion that there is a distinct connection between plasmoma and trachoma, and that the latter may have disappeared in those cases reported as "free" from trachoma.

K. L. STOLL.

DIFFERENTIAL DIAGNOSIS BETWEEN TRACHOMA AND VERNAL CONJUNCTIVITIS. DINULESCU and NESTIANU, Cluj. med., 1929, no. 9.

Three of eleven patients presented the type of limbus efflorescences of vernal conjunctivitis, the others the tarsal, papillary type. The efflorescences at the limbus extended almost throughout the circumference of the cornea and were associated with congestion of the bulbar conjunctiva. Subjectively, severe itching and tension in the eyeballs, particularly during the summer months, was noted. Eosinophils were present in the conjunctival secretion. Histologically, an excised specimen of the conjunctiva showed marked lymphocytic infiltration, but without any tendency toward follicular arrangement as is found in trachoma. Many cells with eosinophil granulations were present.

N. BLATT.

Congenital Anomalies

ATYPICAL COLOBOMA AND VASCULAR ANOMALY. L. BUCHANAN, Brit. J. Ophth. **14:** 68 (Feb.) 1930.

The case reported is similar to the one reported in the *British Journal of Ophthalmology* (vol. 13, p. 608) by Mann and Ross.

The anomaly was found in the right eye of a young man. Vision equaled 6/12. The appearance of the fundus was that of a large coloboma of the choroid with a small band of normal appearance above it. Above the normal band was what appeared to be a small optic nerve entrance with a large ectasia upward. Blood vessels extended in two regular groups, one to the right, one to the left, each containing an artery and a vein. A small vessel extended up along the ectasia and branched. About a disk's breadth above the upper extremity of the ectasia there was another optic nerve entrance of moderately normal appearance. The principal departure from the normal was the distribution of the blood vessels. The veins and arteries at the lower part were small compared with those of the upper part. The vessels seemed to come more from the nasal than from the central part of the nerve. The condition might be due to, or connected with, an unusually placed division of the central retinal artery and vein coincident with, perhaps connected with, the late closure of the choroidal cleft.

W. ZENTMAYER.

Cornea and Sclera

KERATITIS SICCA. W. S. DUKE-ELDER, Brit. J. Ophth. **14**: 61 (Feb.) 1930.

This condition, one of dystrophy of the cornea associated with deficiency of lacrimal secretion, was seen in a boy, aged 5½ years. Except for an absence of tears since birth, the child was normal and healthy. He never wept. Photophobia was marked. Vision equaled 6/9. Sensibility of the cornea was normal. Situated in the deeper layers of the epithelium, and in a few instances involving the superficial part of the substantia propria, there was a considerable number of punctate opacities of each cornea. Some of them were large and diffuse, while others were small and discrete. They were more numerous in the lower segment of the cornea where they were interspersed with a few short tenuous linear opacities. The eyes were dry. Schirmer's blotting paper test gave a subnormal result, while reflex stimulation was subnormal.

Similar cases reported in the literature may be divided into two groups: (*a*) congenital, after trauma or operation, or (*b*) spontaneous in women after the climacteric. The keratitis is frequently associated with the presence of epithelial filaments.

The author prefers to regard the condition as a clinical entity and to refer to it in terms of what appears to be the most important factor in its etiology, keratitis sicca.

W. ZENTMAYER.

CIRCUMSCRIBED ABSCESS OF THE SCLERA. F. TERRIEN and FAVORY. Arch. d'opht. **46**:641 (Nov.) 1929.

The authors first call attention to the thesis of Dollfus, who in 1928 collected all the literature on this subject up to that time. They point out that whereas diffuse inflammation of the sclera commonly called tenonitis is not uncommon, suppurative inflammation is rare though not exceptional. Two types of this condition are recognized by their clinical picture and their gravity, cases involving the anterior segment and

those situated in the posterior portion. The authors think that these cases should be distinguished from those of suppurative tenonitis by their limitation and by their more frequent benignity.

They report a case of posterior abscess which completely healed. This case is of particular interest owing to the fact that the prognosis is not so favorable in the case of posterior abscess, the patient in only one of seven cases reported by Dollfus recovering completely, whereas complete recovery takes place in 72 per cent of the anterior cases. They then report two cases involving the anterior segment, in both of which the patients recovered perfectly. They call attention to the fact that in 90 per cent of the Dollfus' cases the staphylococcus was the causative organism. In two of their cases the staphylococcus was found. Dollfus, in his thesis, points out the resistance of the episcleral tissue to infection, which is a possible explanation for the negative bacteriologic observations in their third case. Early evacuation of the pus usually leads to prompt cure.

S. B. MARLOW.

TATTOOING WITH GOLD CHLORIDE. C. BAER, Ann. di ottal. e clin. ocul. **57:** 900 (Oct.-Dec.) 1929.

Knapp's technic was carefully followed in a case of keratoconus, 1 per cent tannic acid being used as a reducing agent. The immediate result was a black pupil with an improvement in the vision obtained above the scar from 5/50 to 5/15. Three months later, the stained area was beginning to fade, and after nine months the central area was completely decolorized and vision was the same as before the operation. The author proposes to try platinum chloride, which there is reason to believe is not so easily absorbed.

S. R. GIFFORD.

KERATOCONUS, TREATED BY MUELLER'S AND ZEISS' CONTACT GLASS. POPOVICI, Cluj. med., 1929, no. 9.

The author mentions the modes of treatment hitherto in use, viz., pilocarpine, deep thermocauterization of keratoconus with subsequent repeated puncture of the anterior chamber and later tattooing of the thickened corneal scar, hyperbolic glasses, conic glasses, stenopaic diaphragms, contact glasses according to Fick, Sulzer, Kalt and Mueller, also Lohnstein's and Siegrist's hydrodiascope. Detailed descriptions are given of Mueller's blown glass and Zeiss' cut contact glass. The first is said to be better tolerated by patients. The author's patient had vision 1/50; with Mueller's glass it was 5/7; with Zeiss' glass, 3/12, and with a plus 2.75 diopter lens, 1/2. Mueller's glass can be worn for from seven to fourteen days without irritating the eye. His patient has worn Mueller's glass uninterruptedly for six months with one day intervals, after every six days.

N. BLATT.

General Pathology

ANATOMIC STUDIES OF A CASE OF KERATITIS PUSTULIFORMIS PROFUNDA (E. FUCHS). J. IGERSHEIMER, Arch. f. Ophth. **123:** 468 (Jan.) 1930.

The author reports a case from the clinic of von Hippel, in which a man, aged 52, with a four plus Wassermann reaction, developed a severe

inflammation of the left eye, with secondary glaucoma and a marked hypopyon mixed with blood. Clinically the inflammatory changes in the iris and the deep infiltration and abscess formation in the cornea were obscured by the clouding of the epithelium owing to the increased tension. About four weeks after the onset of the inflammation, a puncture of the anterior chamber with a small hypodermic needle was performed and most of the hypopyon withdrawn. Three weeks afterward, paracentesis of the anterior chamber was performed, and after another week the eye was removed. According to Igersheimer, this is the fifth case of keratitis pustuliformis profunda in which the histologic observations have been reported. The other four cases were reported by E. Fuchs and in only one of these was there certainty of the relationship to syphilis. Igersheimer believes that in his case the infiltration and abscess formation in the cornea are secondary to the iritis and hypopyon, since the cellular infiltration in the iris is much greater and more diffuse than that in the cornea, and since the abscess in the cornea is in direct contact with Descemet's membrane and communicates directly, through an opening in Descemet's membrane, with the hypopyon in the anterior chamber. It remains unknown whether the marked leukocytic reaction in these cases of pustuliform keratitis is actually produced by the spirochetes, or whether it is due to a special susceptibility of the patient. No spirochetes were found in Igersheimer's case.

P. KRONFELD.

Glaucoma

GLAUCOSAN, AN EPINEPHRINE SUBSTITUTE, IN GLAUCOMA. B. CASTRESANA, Arch. de oft. hisp. am. **29**: 705 (Dec.) 1929.

After a detailed account of Hamburger's experiments since 1925, with a description of the various clinical effects and mode of employment of different kinds of glaucosan used, the author concludes that this drug at times has a curative effect and at times a temporary palliative effect, permitting the ophthalmologist to make use of operative measures under more favorable conditions.

C. E. FINLAY.

TREATMENT OF GLAUCOMA BY GYNERGEN SANDOZ. Popovici, Cluj. med., 1929, no. 9.

Though he had the opportunity of administering this preparation (in tabloids) in two cases only, he would no longer do without this therapeutic agent. One of the cases was simple glaucoma; here the action of an ergot preparation equaled that of pilocarpine; the other case was one of secondary hemorrhagic glaucoma. Pain subsided, but tension fell only from 70 to 60 degrees.

N. BLATT.

Injuries

REMOVAL OF LEAD SHOT FROM THE VITREOUS. G. H. CROSS, Am. J. Ophth. **13**:41 (Jan.) 1930.

The author's interesting experiences with lead shot are given, and five cases are reported. He advises the prompt removal of shot with a specially constructed forceps and the aid of the double plane fluoroscope in the hands of an expert operator.

W. S. REESE.

REPORT OF A CASE OF THORN UNDER THE UPPER LID. M. R. SAWHNEY, Brit. J. Ophth. **14:** 115 (March) 1930.

The interest in the case lies in the long period that the foreign body remained under the upper lid without exciting symptoms other than lacrimation and photophobia, and the escape of the cornea from damage.

Five months previously, the child had run a thorn into its eye. There was a slight swelling of the lids, congestion of, and mucopurulent discharge from the conjunctiva. A mass of granulation tissue, external to the caruncle, sprouted from the conjunctival surface of the lower lid. From this the thorn projected passing under the medial side of the upper lid. It was readily removed and measured about 1 inch in length.

W. ZENTMAYER.

LESIONS OF THE EYE OBSERVED IN WORKERS IN SULPHUR MINES. H. MITA, Klin. Monatsbl. f. Augenh. **83:** 797 (Dec.) 1929.

Irritation of the surface of the eyes is followed by seeing colored circles around the lights, photophobia and lessened sensitiveness of the cornea. The last-mentioned symptom is replaced by pain in the eyes as soon as the opacification of the cornea begins. This is produced by small and shallow depressions in the corneal epithelium, the result of the destruction of small vacuoles in the protoplasma below the epithelium, as illustrated by microphotograms of the corneas of rabbits. Coagulated substances observed in the aqueous humor are formed by the irritation of the ciliary body as a consequence of the corneal disease, but not as a result of iritis. These ocular lesions are usually transient; they may be accompanied by general symptoms. The iris and fundus are never involved. The corneal disease is mostly limited to the area exposed between the lids.

The author concludes that the symptoms described are caused by direct contact with sulphurated hydrogen impregnating the air in the mines, but not, as pointed out by a number of writers, to toxic influences by way of the blood or respiration. Similar lesions of the eyes were seen in people working in the manufacture of artificial silk, in sugar refineries, soap factories, dye-works and tanneries.

K. L. STOLL.

Lens

THE RESULTS OF OPERATION FOR SENILE CATARACT AT THE OPHTHALMIC CLINIC OF BUCHAREST FROM 1920-1928. MANOLESCU and FLORESCU, Cluj. med., 1929, no. 9.

Regarding the results, the author distinguishes two groups, viz., the immediate results and the end-results of operation. With 579 cataract operations the immediate result as regards vision was as follows: vision, 1 to 1/4 in 44.04 per cent; 1/4 to 1/10 in 23.48 per cent; below 1/10 in 27.46 per cent, and 0 in 4.48 per cent. It was necessary to sacrifice the eyeball in 0.51 per cent. The unsatisfactory results are particularly due to the fact that parts of the capsule and lens remains were left behind, and partly also to irregular astigmatism. The end-results in ninety-four reexamined patients were, on the contrary, better, namely: vision, 1 to 1/4 in 59.53 per cent; 1/4 to 1/10 in 17.02 per cent; below 1/10 in 18.02 per cent, and 0 in 4.25 per cent. It was possible, however, to improve

vision by a second operation. Thus in thirty cases with vision below 1/10 the following results were obtained by subsequent operations: vision, 1 to 1/4 in 44.44 per cent; 1/4 to 1/10 in 22.22 per cent; below 1/10 in 30.55 per cent, and 0 in 2.77 per cent. Complete loss of visual acuity was caused by suppurative keratitis and iridocyclitis, loss of vitreous body, expulsive hemorrhage, panophthalmitis, detachment of the retina and hemorrhagic glaucoma. Poor visual acuity was caused in 80 per cent by secondary cataract, in 12.50 per cent by secondary glaucoma, in 6.25 per cent by vitreous opacities and in 6.25 per cent by iridocyclitis. In 44.17 per cent of all these cases it was possible to improve the visual acuity by discission or extraction. Far better results were attained in those cases in which the lens was extracted in its capsule, namely: 1 to 1/4 in 55.55 per cent; 1/4 to 1/10 in 22.22 per cent; below 1/10 in 22.22 per cent.

(Although these statistical returns of the authors are based on a comparatively small number of cataract extractions (done in a period of eight years), they are, however, especially valuable on account of the exact data and careful, honest analysis of the conditions, as they may and, in fact, do occur in all cataract operations and in all countries. [Reporter's note.])

N. BLATT.

Methods of Examination

ERRORS OF DIGITAL ESTIMATIONS OF INTRA-OCULAR PRESSURE. H. K. MULLER, Arch. f. Augenh. **102**: 668, 1930

A comparison of 1,000 digital determinations of intra-ocular pressure with the actual tonometric readings shows that there is an error in the digital estimation of $\pm$ 33 per cent.

In general, the lower pressures are overestimated and the higher pressures are underestimated.

F. H. ADLER.

Neurology

SUPRASELLAR TUMORS. VIGGO CHRISTIANSEN, Arch. d'opht. **46**: 577 (Oct.) 1929.

The author says that a topographical delimitation of the suprasellar region, even approximately, is impossible. From a clinical point of view, a cleancut symptomatic classification of suprasellar tumors is fictitious. Chiasmal symptoms are the only ones which sometimes, but not always, indicate the exact location at the base of the brain. While the physiologist is able to study and analyze the results of experiments, the clinician is able to observe only poor imitations. He points out that many tumors in the region of the chiasm present so-called suprasellar symptoms. He cites two cases: one with purely visual symptoms, and the other with acromegalic symptoms without visual disturbances.

He discusses a few of the symptoms that are less constant and not generally known. The first is the loss of visual acuity, unilateral at the beginning, without ophthalmoscopic change. He emphasizes the importance of the examination of the visual field and does not agree that it is sufficient to do this with small white test objects only. Bitemporal achromotopsia is often the earliest symptom. He refers to the occur-

rence of a central scotoma and homonymous hemianopia. Roentgenologic evidence is often helpful but not always pathognomonic. Choked disk is rarely observed in these cases. The symptoms may simulate those of a tumor of the frontal lobe.

S. B. MARLOW.

PATHOGENESIS AND THERAPEUTICS OF OCULOGYRIC CRISES. ESTEBAN ADROGUÉ AND MANUEL BALADO, Arch. de oft. de Buenos Aires 4: 683 (Nov.) 1929.

This article consists of reviews, literature and data as recently reported by S. E. Jeliffe *(J. Nerv. & Ment. Dis.,* Jan. to May, 1929), who abstracted over 200 cases published between the years 1921 and 1929.

Almost invariably there is a prior history of a febrile attack with agitation, convulsions and acute choreic attacks. This is followed by a stage of somnolence and finally by parkinsonian rigidity, frequently complicated by salivation, clonus and diplopia.

The oculogyric crises, deviation of the eyes, may occur in any direction, in the following order of frequency: up, down, laterally.

These phenomena may occur spontaneously, as in the author's third case; or they may occur as in his first and second cases, in which they were brought on by directing the patient to look upward. The patient was unable to look down for several minutes, but during this time he could answer questions properly. In some instances there were also violent symptoms, such as convulsions, opisthotones, nausea and loss of consciousness.

The duration of the crises varies from a few seconds to several hours and is characterized by complete lack of control by the patient, repetition of the crises frequently having led the patients to suicide.

According to Stern, these crises come under the classification of Westphal's obligatory movements produced by subjective sensations. There has been much discussion as to whether their origin is purely psychic or whether they are caused by lesions in the cerebrospinal system. Freud considers them purely psychic. Stern, however, mentions their experimental reproduction in animals; he has also observed similar movements in connection with wounds of the cerebellum and basal ganglia, and he considers them the result of anatomic lesions as yet not determined. Stern relates these movements to spasms in other muscle groups, as occurs in yawning. He does not consider them as occurring only in epidemic encephalitis, as they are seen also in paralysis agitans and tabes. These movements are accompanied by a characteristic feeling of anxiety, and finally there is an exaggeration of the laberynthine reflexes and of those of the muscles of the neck. Stern is inclined toward the belief that they are caused by lesion of the vestibular and visual centers.

The author next reports three cases in women. In one there were postencephalitic antecedents of a parkinsonian nature; in the other two, the oculogyric crises appeared alone without any prior pathologic manifestations. In the two latter cases, he suspects a hysterical origin.

In the first case benefit was obtained by the employment of scopolamine; in the other, by a generous use of bromides.

C. E. FINLAY.

Ocular Muscles

ATYPICAL FORM OF THE PHENOMENA OF MARCUS GUNN. J. S. CHARAMIS, Arch. d'opht. **46**:663 (Nov.) 1929.

These phenomena are characterized by a unilateral ptosis, usually incomplete and congenital, with elevation of the lid when the mouth is opened. The author refers to the report of Villard, who in 1925 collected ninety-three cases from the literature. Since this report five other cases have been recorded and the author adds a sixth. In the author's case elevation of the lid is produced by: (1) contraction of the elevating muscles of the inferior maxilla, (2) lateral movements of the jaw to either side, the mouth remaining closed, (3) thrusting forward of the chin by the external pterygoids and (4) during deglutition. The author favors the theory of Fromaget, which suggests a lesion above the nuclei either in the coordinating centers or in the cortex.

S. B. MARLOW.

TRANSITORY MUSCLE PARALYSIS ORIGINATING DURING A SQUINT OPERATION. PANDELESCU, Cluj. med., 1929, no. 9.

A young man, aged 19 years, had convergent strabismus of 20 degrees. Retrobulbar anesthesia was given with procaine hydrochloride epinephrine. When inserting the suture in the tenotomized muscle tendon, the operator became aware of this muscle having entirely relaxed. After the sutures had been tied, both eyes were found to be in correct parallelism, whereas the eye operated on had completely lost its capacity for abduction. Two days after the operation the paralysis disappeared completely. The palsy was probably due to the anesthesia.

N. BLATT.

PARALYTIC SYNDROME STARTING FROM THE ORBIT. VANCEA, Cluj. Med., 1929, no. 9.

A patient, aged 20, had severe headache for four weeks. Ptosis of the right eye and limited movement of the eyeball to the temporal side developed. There was serious diminution of the acuity of vision. Later, the eyeball became quite immovable; exophthalmus and mydriasis developed. Slight opacities of the cornea were observed. There were no pupillary reflexes. Vision in the right eye was 0; in the left eye, 5/5. Edema of the optic disk was noted. There was corneal insensibility, hypertrophy of the inferior turbinate bone and deviation of the nasal septum. The Wassermann reaction was negative. Radiographically, the right optic formen proved to be much narrower than was the left. After one month the eyeball recovered its mobility, and the exophthalmus had disappeared. Atrophy of the optic nerve was left. Treatment was confined to injections of strychnine. The nature of this orbital lesion is, according to the author, not to be made out.

N. BLATT.

Operations

SUBCONJUNCTIVAL IRIDECTOMY FOR GLAUCOMA. L. POST, Am. J. Ophth. **13**:21 (Jan.) 1930.

The author balloons out the bulbar conjunctiva in its upper half with a subconjunctival injection of salt. A Graefe knife is then passed

through this raised conjunctiva 3 mm. above the upper limbus and in a vertical line with the temporal limbus, and the anterior chamber is entered in a line directed to the tip of the nose. The handle of the knife is depressed and the counterpuncture made so that the finished section will comprise about the upper fifth of the circumference of the cornea. The section is completed upward on a plane with the iris, the knife point remaining subconjunctival. At the moment of exit the blade is tilted somewhat forward. The knife is then withdrawn through the original wound in the conjunctiva, which is enlarged to about 4 mm. Through this an iris forceps is passed into the anterior chamber, and the pupillary border of the iris is seized and drawn upward through the limbus section, the iris thus being somewhat everted. The iris is now pulled firmly into the temporal end of the incision, and that part which extends through the scleral section is excised, the scissors being introduced subconjunctivally.

No opportunity has as yet been given to study one of these eyes pathologically. A bleb, larger but not unlike the trephine bleb, results, but the overlying conjunctiva, according to the author, is thicker. One patient recovered from severe pneumococcus conjunctivitis unscathed, which had developed several months after operation. Ten eyes have been operated on by this method and the cases are reported.

W. S. Reese.

Technic to Avoid Hemorrhage During Operation on the Lacrimal Sac. R. Duverger, Arch. d'opht. **46:** 676 (Nov.) 1929.

In spite of the development of the operations to establish drainage into the nose, Duverger points out that extirpation will remain necessary in certain types of cases; in ulcer of the cornea and, for safety, in operations on the globe. He discusses three important features of the operation: anesthesia, dissection of the sac and hemostasis. He prefers regional anesthesia as it is more complete and does not disturb the anatomic relations as does local infiltration. He has adopted the suggestion of Pooley of staining the sac by injecting methylene blue (methylthionine chloride, U. S. P.) as an aid in its dissection. To control hemorrhage he relies on the injection of cocaine and epinephrine into the sac. A solution made up of 1 part of 10 per cent cocaine and 3 parts of epinephrine, 1 : 1,000, to which is added two drops of 1 per cent methylene blue, is used to irrigate the sac three or four times before the operation is begun. With this technic, he states, the operation can be performed with a dry field provided no large vessel is cut.

S. B. Marlow.

Orbit, Eyeball and Accessory Sinuses

Hemangioma of the Orbit. J. B. Hamilton, Brit. J. Ophth. **14:** 65 (Feb.) 1930.

A woman, aged 40, had a fairly extensive capillary nevus on the left side of the face. The left eye showed a generalized dilatation of the scleral vessels with deep purplish coloration of the sclera near the equator. There was edema of the retina with pigmentary degeneration

of the macula. Physical examination was negative except for an increased density of the left orbit as compared to the right.

In view of the facial nevus and the roentgen report, it was considered that there was a nevus of the choroidal and orbital vessels causing a slight back pressure which was exhibited by engorgement of the vessels in the sclera and by edema in the retina.

W. ZENTMAYER.

Physiology

THE ORIGIN, PHYSIOLOGY AND PATHOLOGY OF INTRA-OCULAR PRESSURE. PART 1. R. SONDERMANN, Arch. f. Augenh. **102**: 110, 1929.

The author discusses the present theories of the origin and formation of aqueous humor and the maintenance of normal intra-ocular pressure. He points out that in the development and growth of the eyeball, the fibers of the scleral coat gradually compress the vessels at their entrance and exit from the globe. This increasing pressure is naturally more effective on the veins that have thinner coats, and this leads to a damming up of blood in the chorioidal reservoir until a pressure is arrived at which may be considered the normal for that particular eye.

He measures the pressure in the veins leading from the eye by inserting a cannula directly into the vein at various distances from its point of exit. The details of experimentation and the errors to be avoided are carefully described.

In twenty-eight rabbits' eyes, the mean pressure in the vortex vein as it leaves the eye measured from 55 to 62 mm. of mercury. There is an immediate fall of pressure in the vein beyond its point of exit, and this may explain some of the variations in the figures given by different authors.

The mean intra-ocular pressure in these experiments measured 27 millimeters of mercury. Since the capillary pressure approximates the venous pressure, it is evident that the capillary pressure in the uveal tract is sufficient to account for a formation of aqueous on the basis of a simple dialysis. Further observations show that the pressure in the uveal veins and capillaries must be at least from 25 to 30 mm. of mercury higher than in the corresponding vessels of the retina. One cannot reason, therefore, from pressures found in the retinal system as to the possibility of aqueous formation by the laws governing a dialysate.

F. H. ADLER.

THE ORIGIN, PHYSIOLOGY AND PATHOLOGY OF INTRA-OCULAR PRESSURE. PART 2. R. SONDERMANN, Arch. f. Augenh. **102**: 434, 1930.

In the preceding abstract, the author has shown that the intra-ocular pressure originates in the blood pressure of the intra-ocular vessels. This is made possible by the constriction at the points of exit of the uveal veins occurring during fetal life. The pressure in the veins and capillaries of the uvea is different from that in the circulation of the retina. It is always higher in the former. The intra-ocular pressure is a function of the blood pressure in the uveal capillaries. This second article deals with a general discussion of the problems of the formation of aqueous.

The author concludes that there is a condition of equilibrium maintained between the intra-ocular and the intravascular pressures which is normally upset only during each systole and diastole. On these changes in pressure depend the filtrative forces of the eye. The metabolism in the eye is relatively small. In general there exists a marked similarity between the formation of urine by the glomerulus of the kidney and the formation of aqueous by the ciliary bodies. The secretion of the ciliary bodies is characterized as an active secretory separation of an ultrafiltrate.

There exists a fluid stream in the anterior chamber which, however, is very small. The normal content of Schlemm's canal is aqueous. The pressure in Schlemm's canal is somewhat less than in the anterior chamber but higher than in the ciliary veins at their point of exit from the eye. The aqueous leaves the eye through Schlemm's canal and also by way of the capillaries of the anterior surface of the iris. This is brought about through Schlemm's canal by filtrative forces, whereas the carrying off of aqueous by the capillaries of the iris is due to osmotic forces. The intra-ocular pressure in inflammations of the anterior segment depends essentially on the development of the perforating vessels of the sclera in this region, particularly the veins, and also on the conditions of outflow from the anterior chamber. The hypotension of old cyclitic eyes is due to the dilatation of the veins in the anterior portion of the sclera. The capillaries of the normal ciliary body usually show marked constriction of the caliber with increasing age, whereas the other capillaries are usually dilated.

In two cases of glaucoma simplex without inflammatory changes, the author found well marked degeneration in all of the ciliary processes, marked thickening of the pectinate ligaments and relative constriction of Schlemm's canal. These changes may play a definite part in the origin of glaucoma simplex.

F. H. ADLER.

THE GASEOUS INTERCHANGE BETWEEN THE CORNEA AND AIR. F. P. FISCHER, Arch. f. Augenh. **102**: 146, 1929.

If the intact living cornea is surrounded by pure carbon dioxide instead of air, it becomes cloudy after from one to two hours. This cloudiness is due to a change in the endothelium. The epithelium remains unchanged. On the other hand, if the cornea is exposed to pure hydrogen or oxygen, it remains unchanged. Bullot and Lohr found that enucleated rabbits' eyes inserted into the peritoneal cavity of other rabbits became cloudy if the epithelium was intact. If the epithelium was removed, the cornea remained clear. Apparently, the clouding of the cornea is due to a necrosis of the endothelium which occurs only if the epithelium is present. These experiments could also be repeated when the eyes were kept in a moist chamber. These authors concluded that the epithelium kept oxygen from the endothelium. The experiments showed that the endothelium needed considerable oxygen and during life depended on the oxygen of the aqueous, which is guaranteed with an intact circulation in the living eye. When the oxygen cannot be supplied from the aqueous, the endothelium draws on the oxygen of the surrounding air.

In order to gain further insight into the gaseous interchange of the cornea with air, Fischer carried out the following experiments:

An airtight glass chamber was placed over the cornea and was so arranged that the cornea could be exposed to a known volume of air or any gas for a definite period and then an analysis was made of the gas in the chamber. The analysis of the gas was done by the Krogh micro-gas buret. The method is given in detail with all the precautions that must be taken to insure accuracy. The experiments show that the oxygen in the air can penetrate the epithelium, and this is apparently utilized by the endothelium. Carbon dioxide permeates the cornea in the opposite direction, apparently coming from the aqueous and being given off to the surrounding atmosphere. The epithelium offers an obstacle to the passage of oxygen and carbon dioxide through it but it is, to a certain degree, permeable to these gases. It does not use any oxygen itself and gives off no carbon dioxide to the surrounding air. While the oxygen of the air is unnecessary for the maintenance of the endothelium, the latter quickly dies if the carbon dioxide output into the surrounding atmosphere is prevented. Oxygen and carbon dioxide can permeate the cornea only in one direction, i. e., oxygen in toward the aqueous, carbon dioxide outward into the air. An analogy is drawn between the permeability of the capillaries and that of the cornea.

F. H. ADLER.

Refraction and Accommodation

ACCESSORY EFFECTS OF THE CORRECTING GLASS BY ITS POSITION BEFORE THE AMETROPIC EYE. A. COWAN, Am. J. Ophth. **13**: 24 (Jan.) 1930.

This interesting article is a practical exposition of certain phases of physiologic optics and must be read to be appreciated. Indeed, any one who refracts should read it studiously. The subject is taken up under the following headings: (1) the prismatic effect of a correcting lens; (2) the effect of tilting the correcting lens, and (3) the effect of distance between the eye and the correcting lens.

W. S. REESE.

Retina and Optic Nerve

SOME OBSERVATIONS ON THE CAUSES AND TREATMENT OF SIMPLE DETACHMENT OF THE RETINA. H. B. STALLARD, Brit. J. Ophth. **14**: 1 (Jan.) 1930.

This paper presents some observations made on the history, physical signs, treatment and subsequent progress of 100 patients suffering from simple detachment of the retina. Fifteen of the patients were seen at St. Bartholomew's Hospital, and information concerning the remainder was obtained from reliable case notes taken by English, American and Continental ophthalmic surgeons.

The author defines simple detachment of the retina as a line of cleavage formed between the layer of pigment epithelium and the percipient neural portion, over a part or the whole of the retina. The intervening space between these layers is filled with a fluid, the nature of which is either physiologic or pathologic.

The following summary of treatment is given:

1. Early treatment is most important.

2. Conservative principles must be adopted for two or three weeks. If at the end of this time the retina is not reattached, operative measures are indicated if the case is suitable for such. Pathologic changes in the vitreous and the uveal tract or a perforating injury are contraindications to an operation.

3. All the operative measures adopted for this condition are unsatisfactory, but scleral puncture and drainage of the subretinal fluid afford better results than any of the others.

4. Detachment frequently recurs two or three days after scleral puncture. The operation should be repeated a week or so later.

5. On discharge from the hospital, the patient must be instructed as regards prophylactic treatment; i. e., he must avoid strenuous exercise, jolts and blows.

The prognosis is summarized as follows:

1. The prognosis is always grave.

2. It is more favorable in patients suffering from detachment due to trauma, without a perforating injury, and in cases of detachment associated with albuminuric retinitis of pregnancy.

3. It is unfavorable in cases in which the eye is grossly diseased as a result of an old perforating injury or inflammation, or in which there has been a previous detachment.

4. The results of treatment are less favorable in myopes.

W. ZENTMAYER.

So-Called "Azotemic" Retinitis. F. Terrien and Renard, Arch. d'opht. **46:** 594 (Oct.) 1929.

The authors first discuss the term "albuminuric" and suggest that it would be better to call this condition "renal retinitis," as nephritis is always present while albuminuria may or may not be constant. Although it is generally considered that this retinitis is the direct result of the nephritis, nevertheless some cases have been reported in which the retinitis seemed to have been the first symptom of the nephritis. The authors refer to the observations of Widal and Morax who found nitrogen retention in all the cases they studied and therefore considered the condition as a nitrogenous retinitis. The authors object to this point of view because there are some cases in which the nitrogen retention is very slight. They report two cases of this kind. These two patients were found to be entirely normal except in regard to three points: (1) marked hypertension which responded to treatment, (2) cholesterinemia considerably above normal and (3) an elevated Ambard's constant.

They discuss at some length the presence of cholesterol in the tissues of these patients and raise the question as to its toxicity. They discuss still further the vascular changes that are almost always present, and believe that the retinal changes are chiefly dependent on these. They feel that the ophthalmoscopic picture is produced by the association of many factors which also produce profound alteration in the general condition leading to hypertension and changes in the chemical composition

of the blood. They believe that nephritis is always present and due to the same cause, and they therefore suggest that the prognosis should be guarded.

S. B. MARLOW.

CHOKED DISK. ANTONIO J. MANES, Arch. de oft. de Buenos Aires **4**: 702 (Nov.) 1929.

The author calls attention to the fact that choked disk does not signify cranial hypertension as invariably as is usually supposed. He mentions its production in certain local lesions of the eye (traumatisms, operative loss of vitreous in cataract operations), and also in certain conditions of the blood (policithemias and chloroses).

He reports two cases; one was due to erythrocytosis and the other was a unilateral choked disk in intermittent crises of intense cranial hypertension.

C. E. FINLAY.

TRAUMATIC BILATERAL OPTIC ATROPHY RESEMBLING THE HEREDITARY TYPE AS DESCRIBED BY LEBER. A. BETSCH, Klin. Monatsbl. f. Augenh. **83**: 814 (Dec.) 1929.

A man, aged 28, suffered an accident with his motor-cycle five weeks prior to his admission to the hospital. He had been unconscious for a day but was able to take up his work a week later. Hemeralopia, vertigo and headache had not been present. His vision began to fail about a month after the injury. Central absolute scotoma, contracted field for colors in both eyes and pallor of the temporal portions of the disks were noticed on admission; the vision was reduced to 5/60 and 4/60, respectively. These symptoms increased in the course of the following months, coming to a standstill a half year later. The central scotomas had finally extended into the periphery, as such extension was also observed in several patients of Wilbrand and Saenger, and in one of Roenne's. Although the same symptoms were found by Leber in hereditary atrophy of the optic nerves, no distinct evidence of hereditary affliction could be established in this case.

K. L. STOLL.

Trachoma

A PRELIMINARY NOTE ON BACTERIOLOGICAL RESEARCH INTO THE ETIOLOGY OF TRACHOMA. R. P. WILSON, Third Ann. Rep., Giza Mem. Hosp., Cairo, 1928, p. 74.

After reviewing the work of Noguchi, the author details the experimental work from which he draws his own conclusions. Smears from active trachoma were examined to determine the presence or absence of (*a*) Prowazek bodies or (*b*) any specific organism which might be regarded as an etiologic factor in the disease. It was rare to find Prowazek bodies or any other intracellular inclusions. No organisms suspected of being etiologically related to trachoma could be constantly demonstrated, although small gram-negative bacilli were occasionally observed in very small numbers. Importance could hardly be attached to the latter, owing to the frequent presence of the Koch-Weeks bacilli and others.

Recently, a pure culture of an organism obtained from tissue removed from nontrachomatous patients—after inoculation with the infected material—yielded a small, suspicious, gram-negative bacillus closely resembling the organism described by Noguchi, but which showed cultural tendencies to develop gram-positive character, thus resembling the xerosis bacilli.

W. ZENTMAYER.

THE ETIOPATHOLOGIC PROBLEM OF TRACHOMA. R. P. WILSON, Third Ann. Rep. Giza Mem. Ophth. Lab., Cairo, append. no. 3, p. 78, 1928.

With great difficulty success was obtained in growing gram-negative bacilli which appeared to correspond in all respects with that isolated by Noguchi. As some of the monkeys examined for experimental purposes were found to have normally a few well defined, yellowish-white, gelatinous looking, discrete follicles scattered over the upper and lower fornices, this presented difficulties in view of the possibility of trachoma occurring spontaneously in monkeys. Histologic and clinical study of these tissues led to the conclusion that follicles may sometimes be present in the normal conjunctiva of the monkeys, but that in most cases the follicles are an evidence of a simple folliculosis. It is in no way related to trachoma in man.

Difficulty arises over the interpretation of the direct inoculation experiments with scrapings from an acute case of trachoma. At one stage of the disease induced, the clinical appearances of the two cases closely resembled trachoma, but the course in each case, together with the absence of pannus and definite scar tissue, is against the diagnosis of trachoma. The presence of follicles on the tarsus and the minute corneal changes are points of great importance and one cannot entirely rule out the possibility of the condition being trachoma, but it is improbable, and in human eyes the author would not have made the diagnosis of trachoma.

Three of the four animals inoculated with the gram-negative bacillus developed follicles, but in two of these follicles likewise appeared in the control eye. Adopting the same criterion as before these were not trachomatous but a more or less typical follicular conjunctivitis, similar to that occurring naturally in monkeys. After seven months the follicles remained unchanged but no scarring or vascularization of the cornea has followed. (The article is illustrated with colored drawings.)

W. ZENTMAYER.

Tumors

SARCOMAS OF THE UVEA. E. VON GRÓSZ, Arch. f. Augenh. **100-101:** 236, 1929.

The author discusses the general prognosis of sarcomas of the uveal tract. About 50 per cent of patients die from general metastasis. Although it is advisable to enucleate early once the diagnosis is made, the figures of von Hippel show that the prognosis is not essentially worse in the second stage of the tumor than in the primary stage. Grósz advises puncture of the globe with removal of subretinal fluid to determine the presence of sarcoma cells in order to make a diagnosis. A series of interesting cases is described.

F. H. ADLER.

MIXED TUMOR OF THE EYEBROW. G. GERLACH, Klin. Monatsbl. f. Augenh. **83**: 807 (Dec.) 1929.

A tumor the size of a hazelnut was removed from the eyebrow of a man, aged 50. It was of about seven to eight years' growth, had a horny surface and a well defined capsule which allowed a complete removal. Histologic examination revealed the presence of a mixed neoplasm, as it is found in the salivary glands, especially the parotid, in the palate, lips, cheeks and in the tear glands. It contained hair follicles; sebaceous glands; chondroid tissue, interspersed by formations of an epithelial character; furthermore, there were cystic vacuoles. Some of these vacuoles were filled with colloidal substances, and their inner lining showed horny formations and calcifications. The author compared some isolated portions of the tumor with Brooke's "epithelioma adenoides cysticum." Similarities are seen to the mixed tumors of the face described by Paus in 1922. The origin may be fetal in accordance with the views of Paus and of Cohnheim. There was no indication of malignancy, notwithstanding the multitude of cells in this tumor, nor had any recurrence been observed four months after the operation. The location of this type of tumor in the brow is considered unusual.

K. L. STOLL.

Uvea

ACQUIRED HETEROCHROMIA AFTER RESECTION OF THE TRIGEMINUS. V. SABA, Ann. di ottal. e clin. ocul. **57**: 864 (Oct.-Dec.) 1929.

A patient who had undergone resection of the first and second branches of the left trigeminus a year before, for trifacial neuralgia, noticed a change in color of the left iris. It was of a grayish green color, much lighter than that of the right eye. The eye showed deep congestion, numerous precipitates on Descemet's membrane, and a few cells in the anterior chamber. A fibrinous exudate covered the iris. The pupillary reactions were abolished and the pupil was dilated. Tension was increased to 40 mm., dropping to normal under treatment, during which the inflammatory signs also cleared up. With the disappearance of the exudate, the heterochromia was not so marked, but a distinct decrease in pigmentation remained.

The various theories of heterochromia are discussed, the part played by disturbances of the sympathetic innervations of the eye being especially emphasized. In his case, it seems obvious that the heterochromia was due to injury of the sympathetic fibers as they pass from the gasserian ganglion to the ciliary ganglion. The cyclitis was evidently the result of this sympathetic disturbance.

S. R. GIFFORD.

Sympathetic Ophthalmia

TREATMENT OF SYMPATHETIC OPHTHALMIA BY AUTOSERUM. R. GUIRAL AND R. J. GUIRAL, Arch. de oft. his. am. **30**: 1 (Jan.) 1930.

This paper supplements one published in the same *Archivos* **23**: 563, 1922. The authors consider the disease to be much more frequent

than is believed by most authors and are enthusiastic supporters of Wood's etiologic theory of disintegration of the uveal pigment, which, acting as a foreign protein, produces antibodies with a hypersensibility of the sympathizing eye. After a brief survey of the pathologic anatomy and symptomatology, they insist on the benefits obtained by the use of injections of the patient's autoserum, which they say should be used repeatedly and to the exclusion of all other treatment, the injured eye never being enucleated. Their reported results are uniformly favorable when their method is applied early.

They usually base their diagnosis on pigment changes observed with the biomicroscope in the iris and on the corneal surface and in pupillary area of the sympathizing eye. They insist on the necessity of thus examining daily the sound eye in all cases of eye injury.

C. E. FINLAY.

Therapeutics

SUBCONJUNCTIVAL INJECTION OF NEUTRAL ATROPINE SULPHATE IN OCULAR THERAPEUTICA. R. PERRIN, Arch. d'opht. **46**: 672 (Nov.) 1929.

The author points out the advantage of this method of administering atropine in ulcers of the cornea, keratitis, iritis and iridocyclitis. It is used to reenforce instillations when these are not sufficiently effective. He injects 2 minims (0.12 cc.) of a 1:200 solution in adults and ½ minim (0.03 cc.) in children. The injection should be repeated only after an interval of eight days. It is a powerful therapeutic procedure and free from toxic effects if used judiciously.

S. B. MARLOW.

Society Transactions

EDITED BY DR. GEORGE S. DERBY

THIRTEENTH INTERNATIONAL OPHTHALMOLOGICAL CONGRESS

Amsterdam, the Netherlands, September, 1929

ABSTRACTED BY PERCY FRIDENBERG, M.D.

Continued

DISCUSSION OF PAPERS ON IONTOPHORESIS OF MYDRIATICS IN OPHTHALMOLOGY

DR. CORDS, Cologne, Germany: What is the mode of increased action of mydriatics? The absorption and mydriatic action of epinephrine in the presence of erosions may be due to epithelial lesions.

DR. ROCHAT, Groningen, the Netherlands: This factor has been allowed for. Experimental erosion of normal rabbit's cornea showed a much slower and weaker effect of a solution of atropine than the iontophorized eye, or none at all.

MECHANICAL FACTOR IN CORNEAL COMPLICATIONS OF TRACHOMA. DR. SPASSKY, Smolensk, Russia.

Animal experiments show that ulcers, infiltrations, and so on, develop more rapidly and run a more serious course if artificially subjected to pressure by the cornea. This may be prevented by keeping the lid pressure off the cornea by the author's simple and easy procedure of introducing subconjunctivally a pericorneal protective wall or dam of fat or cellular tissue. This operation can be repeated, if need be, and the transplanted wall removed after healing of the ulcer or pannus.

DEPENDENCE OF SUCCESS IN CORNEAL TRANSPLANTATION ON BLOOD CONDITIONS. DR. MAJEWSKI, Cracow, Poland.

Experiments in homeoplastic transplantation have so far given equivocal or contradictory results. The blood conditions represent only one of the determining factors as indicated by blood grouping of donors and recipients in my cases.

COWPOX LYMPH INOCULATION IN METASTATIC OPHTHALMIAS. DR. BLATT, Siebenbuergen, Roumania.

This "interference" therapy (Hallerworden) by which a newly inoculated disease process complicates and beneficially (for the patient) interferes with an old one was used with good results in deep corneal ulcer, severe iridocyclitis and optic neuritis. Two cases of metastatic purulent choroiditis were not improved.

DISCUSSION

DR. D. V. GIRI, Eastbourne, England: Cowpox inoculation is dangerous and may cause encephalitis. Nonspecific or other protein therapy is harmless and preferable by all means.

DR. HILDESHEIMER, Berlin, Germany: If we consider the eye as an organism, irritation or infection of one intra-ocular structure or tissue may favorably affect a disease process in another, at a distance. In a large number of intra-ocular cases a subconjunctival injection of epinephrine-procaine hydrochloride will effect a cure of diseases of the eye, especially if a small pustule forms at the site of injection. It is a common observation that diffuse conjunctivitis clears up quickly if there happens to be a stye at any point on the lid. Surprising therapeutic results were obtained in cases of scleritis, severe phlyctenulae and chronic iridocyclitis by this simple form of counter-irritation.

DR. OHM, Bottrop, Germany: I saw a patient with severe, obstinate and obscure inflammation of the lid margin and conjunctiva treated without effect for weeks. Pneumonia with high fever developed. The eye trouble disappeared "like magic," and did not come back after the lung condition had healed.

PLASTIC OPERATION ON THE CONJUNCTIVA. DR. VON ROETTH, Pecs, Hungary.

The first principle in cases of extensive destruction or symblepharon is to replace the lost tissue by freely undermining the remaining conjunctiva from the limbus toward the fornix where it is turned over and fastened by Arlt traction sutures. Grafts with or without pedicle may be needed. The denuded sclera and fornix are covered with buccal mucosa. The transplant is sutured at one margin to the tendon of the superior or inferior rectus, and at the other, at one side, to Tenon's capsule. In this way, shrinking is avoided. This procedure, successfully applied in eight cases, is also most useful in the restoration of contracted socket.

DISCUSSION

DR. THEIS, Dessau, Germany: In all cases of corrosion and burn, early transplantation is feasible if there is a healthy bed. This is difficult to determine in alkali burns with lye and especially with ammonia which has a depth action, diffuses rapidly and has been found in the aqueous in ten minutes. Denig goes too far in recommending early grafting in all cases in which there is even the slightest corneal involvement. An early plastic operation is indicated when there is definite demarcation of the necrotic area (from the fourth to the tenth day). There must be no trace of serious burn of the underlying sclera or episclera which would prevent healing of the transplant. Burns without necrotic demarcation heal of their own accord, with or without scar formation. Extensive fixation of the flap is requisite.

DR. FRACASSI, Arezzo, Italy: I recommend sclerectomy and sclerotomy, ab externo (Foroni), in simple and acute glaucoma. Mercury and arsphenamine gave excellent results in three cases of extensive retinal detachment in myopic eyes. I use a detached portion

of the orbicularis muscle in trichiasis to insure correct healing and position of the cilia and lid margin. In serpent ulcer I cauterize the margins and bottom with chloride of zinc if there is evident progression into the corneal tissue, and I keep the lids firmly closed by plaster adhesive strips which are changed at each treatment. This is important for cure.

Dr. Botteri, Zagreb, Yugoslavia: I secured almost complete reattachment and cure of extensive ablatio retinae in three months by energetic antisyphilitic treatment in a patient with a 4+ Wassermann reaction.

Dr. Fukala, Vienna, Austria: I advise the treatment for severe intra-ocular disease, such as choroiditis, neuritis and iridocyclitis, with alternating external applications of a 1 : 4,000 solution of bichloride of mercury and the installation of ethylmorphine hydrochloride. The efficacy depends on free absorption of mercury ions.

Orbital Anesthesia. Dr. V. Liebermann, Budapest, Hungary.

There are no counter-indications, but the method is of especial value in magnet operations and advancements. Hematoma and infection are dangers to be avoided. A new anesthetic is recommended as more active and less toxic than procaine hydrochloride.

Roentgenography of Lacrimal Passages. Dr. Castresana, Madrid, Spain.

I tested the permeability of the lacrimal passages with roentgenography after the injection of iodized poppy seed oil 40 per cent. The form, dimensions and caliber of the nasolacrimal duct and the effects of operation are thus easily controlled.

Medical Treatment for Senile Cataract. Dr. Peters, Rostock, Germany.

Heredity and dyscrinisms are both factors. In testing the effect of iodine, for example, one must consider various forms of lens capacity, the stationary lamellar cataracts and coronary, nonprogressive and cortical forms, as well. Endocrine deficiency may be inherited and so predetermine changes in the lens. Tetany, causing cataract, can be influenced, and it is worth noting that there is a previous history of cramps in the fingers and toes in many cases of senile cataract, and with the development of lens opacities after removal of the parathyroids. Polyglandular substitution therapy (parathyroid) and calcium are indicated. Careful visual tests and records and measurements of the opacities are important.

Calcium in Incipient Cataract. Dr. Hildesheimer, Berlin, Germany.

I have given up intravenous injections of calcium. I administer calcium iodide internally with a 2 to 3 per cent solution of calcium chloride and sodium iodide, equal parts, four or more times daily. No progress of opacity was noted in any of these cases. Before giving iodine internally, thyrotoxicosis must be excluded. A decided diminu-

tion of lenticular myopia was noted, indicating that the giving up of fluid altered the shape of the lens. In senility the lens capsule epithelium may be permeable for these solutions. Fissures and drops may also disappear. In juvenile cataract there was always evidence of tetany. Calcium is the prime medicament in all manifestations of tetany. Senile cataract may also depend on parathyroid dyscrinism.

DISCUSSION

DR. STEINDORFF, Berlin, Germany: There has been no advance since the first International Congress (Brussels, 1857) went on record against nonoperative treatment for cataract. No trace of iodine has ever been found in the lens after installation, oral administration, iontophoresis or intravenous injection, even with the unusually delicate colorimetric tests of Raboudin and others.

DR. G. ERLANGER, Berlin, Germany: The failure to find iodine in the lens does not prove, as claimed by the previous speaker, that it has no effect on that organ. It is possible that it acts indirectly after being taken up by the iris and ciliary body.

DR. LOEHLEIN, Jena, Germany: The actual entrance of iodine into the lens may not be the essential point, and the negative results of examination and tests for iodine in the lens of rabbits' eyes do not by any means prove that it does not get under the altered epithelium and possibly the degenerated capsule of the senile lens with beginning opacities. Roemer's series of 1,000 cases, carefully studied and accurately recorded, showed that half the patients who were treated acted exactly like those who were not, i. e., in some the opacities remained stationary, and in others they progressed.

DR. KENEL, La Chaux de Fonds, Switzerland: I use eye baths of 0.8 per cent sodium iodide and calcium chloride. Calcium may be the important element. My results were excellent, but the treatment must be kept up for a long time.

DR. N. BLATT, Targu-Mures, Roumania: I have used iodine salves locally in the eye and internally. In many cases the fellow eye remained clear for ten years. We must warn patients that the treatment is experimental or they will blame the method for a possible increase of opacity.

DR. JESS, Giessen, Germany: Studies with Professor Fischer, neurologist in Giessen, fail to show any relation between senile cataract and parathyroid dyscrinism.

A NEW OPTOMETER. DR. VERWEY, Durban, Union of South Africa.

I use an apparatus presenting successively lenses of increasing refraction to relax gradually accommodation in cases of abnormal tonus or spasm. This method is better than cycloplegia by drops, to determine the strongest plus glass that will be accepted. My method is simpler, especially with children, to increase steadily the strength of correction by a "sliding" advance.

CONTACT GLASSES IN AMETROPIA. DR. HEINE, Kiel, Germany.

I have a set of lenses, ground by Zeiss, with an optically active radius of from 5 to 11 mm. which can be used in hyperopia up to 15

diopters and in myopia to 20 diopters and in all degrees of astigmatism. For various distances, spectacles have to be worn, in addition. The introduction of these lenses meets with no difficulties, but they must be carefully adjusted to cornea and sclera. Muscle imbalance disappears. Accommodation and field show more normal conditions than under spectacle lenses. This is important for architects, aviators, motorists, swimmers, etc. The psychologic (cosmetic) effect, particularly in women, is of importance. A possible beneficial action, by suction and pressure, in ametropia must be thought of. If these shells are worn all day, intra-ocular tension is found to be lower by night, even in glaucomatous eyes.

OLIGODENDROGLIA OF VISUAL PATHS. DR. E. LOPEZ, Madrid, Spain.

We distinguish fibroglia, protoplasmic glia and oligodendroglia. The last was considered an apolar structure until lately and corresponds to the mazoglia of Robertson. The elements show a round chromatin-rich nucleus and little somatic (cell) protoplasm. The processes are numerous and fork immediately after emerging. They are rarely found in the lamina cribrosa and never in the nerve head.

ANATOMY AND PHYSIOLOGY OF SCHLEMM'S CANAL. DR. SONDERMANN, Freiburg, Germany.

1. The inner wall is not separated from the capillary spaces of the ligamentum pectinatum by a continuous endothelial layer. Open canaliculi are found in many places. 2. They are more numerous than the connecting vessels to the ciliary veins but their caliber is generally narrower. 3. The canaliculi can probably take up fluid from the capillary spaces and carry it to the spaces of Schlemm. The presence of these canaliculi and changes in their caliber with alteration in the depth of the anterior chamber or various states of pressure in the ciliary veins indicate that the pressure in Schlemm's canal is identical with that in the anterior chamber, and that they contain aqueous, at least in the normal, unhandled eye.

HISTOLOGY IN CONGENITAL ANIRIDIA. DR. SEEFELDER, Innsbruck, Austria.

Cataract extraction was performed in a case of bilateral, complete aniridia. There was no macroscopic or microscopic evidence of a fovea centralis. Other developmental defects showed that the retinal abiotrophy was the main factor in aniridia. In spite of these observations, there had been fairly good vision for distance and near work after correction.

PIGMENT MIGRATION AND CORNEAL REGENERATION. DR. LOEHLEIN, Jena, Germany.

After complete abrasion of the cornea of the rabbit the regenerated epithelium shows extensive brown pigmentation, due not to new formation but to immigration from the pigmented epithelium of the limbus. Mechanical factors, including lid pressure, are of importance in regeneration of corneal epithelium.

LENS SUBSTANCE AND UVEAL PIGMENT AS A FACTOR IN CONGENITAL EYE DEFECTS. DRS. DAVIS and SMITH, Madison, Wis.

Active immunization of pregnant rabbit does with lens substance and uveal pigment resuted in but a single positive result (buphthalmos) in one young rabbit. Coloboma and microphthalmia are found in healthy and apparently normal litters.

TRANSILLUMINATION UNDER PRESSURE ON THE SCLERA. DR. TRANTAS, Athens, Greece.

I use this procedure in sympathetic ophthalmia when it is valuable to show that the uveal vessels have become invisible while those of the retina are still plainly seen. It is also useful to detect spontaneous retrochoroidal hemorrhage and to note the exact location of rupture (tear? P. H. F.) in retinal detachment.

EXPERIMENTAL PRODUCTION OF CONJUNCTIVAL PIGMENT—GROWTHS. DR. LOEWENSTEIN, Prague, Czechoslovakia.

I had noticed numerous pigmented nodules, from 0.2 to 2 mm. in diameter, in the lid conjunctiva and transition folds of a patient who had instilled epinephrine into the eyes several times daily for nearly fifteen years. Experimental reproduction of the instillation in rabbits gave negative results even after years, but subconjunctival injection of epinephrine, twice weekly, was followed after a time by a local epithelial melanosis. These data confirm Neuburg's view that melanin is an oxidation product of epinephrine and that melanin synthesis is a function of epithelial cell metabolism.

DISCUSSION

DR. POOS, Münster, Germany: I used subconjunctival injections of epinephrine near the limbus in rabbits repeatedly and for a long time. Soon (? P. H. F.) foci of fatty degeneration developed which did not disappear for a long time. Continued irritation of circumcorneal tissues may lead to a mobilization of the pigment cells at the limbus and their emigration into other tissues, but the chemical nature of the irritating substance, epinephrine in this instance, may have little or nothing to do with the case as far as a specific significance for pigment new-formation is concerned.

DR. LOEWENSTEIN: Dr. Poos' objections naturally apply only to the possibility of superficial pigmentation developing as a result of traumatic irritation, but never to the appearance of deep pigmented nodules as seen clinically and in animal experiments.

SURGERY VERSUS RADIUM IN EPITHELIOMA OF THE LIDS. DR. VILLARD, Montpellier, France.

Cure is not invariable with radium, and its use sometimes results in an ugly scar adherent to underlying tissues. The eye may be so damaged as to require enucleation. Small, accessible growths that can easily be removed without disfiguring scars or a necessity for a plastic after-operation may be treated with radium or surgical measures, preferably the latter. Larger, deeply infiltrating epitheliomas are less accessible

and more difficult to extirpate. In spite of probable disfigurement or need of plastic procedures, an operation is to be preferred as in such cases radium is not effectual or the large doses required result in injury to the eye. An extensive inoperable epithelioma should be treated with radium, but may also require far-reaching removal of tumor tissue, in spite of the slight prospect of success. Each method has its advantages and disadvantages, its indications and counterindications.

DISCUSSION

Dr. Scheerer, Tubingen, Germany: At least 80 per cent of lid epitheliomas, if they have not been handled before, heal permanently under roentgen rays, some after a single application. Generally, from one to three radiations at intervals of eight weeks are requisite. Annoying scars or injuries of the globe have not been seen. In obstinate cases the patients can always be operated on later, and less extensive surgical measures are required than if the growths are primarily excised. Poor results of roentgen treatment are noted in cases in which there was relapse after operation. We do not irradiate these patients, but operate primarily. There is no clinical difference, in this respect, between cancer of the skin of the lid and that of the conjunctiva.

Dr. Cords, Cologne, Germany: Roentgen rays act splendidly in pure epithelial cancer (Horn-krebs) of the lid. In basal cell carcinoma of the lid margin which involves the conjunctiva, we must operate or use electrocoagulation.

Dr. Teulières, Bordeaux, France: A small epithelioma "madrilaire" (? P. H. F.) on the free border of the lid which has not yet reached the conjunctiva can be simply removed without a blepharoplastic operation. When it is larger and involves the conjunctiva, radiation or diathermy coagulation (cold cautery) is preferable. In severe ulcerative cases, radiation is the only treatment left. A more or less indrawn and depigmented scar is left which often requires a subsequent plastic operation on the lid, but the operation then meets with more favorable conditions than immediately after excision of the growth. Cooperation with the roentgen therapist is important. The cornea must be protected.

Dr. Dupuy-Dutemps, Paris France: Excision of epitheliomas is the procedure of choice, as it protects most surely against relapse and metastasis and represents a permanent and definite cure. Not all cases can be cured by radiation. This treatment is not reliable and may be dangerous to the eye. It is always futile, once the conjunctiva has become involved. It is deceptive and the final result may remain in doubt for a long time. Diathermy also seems to induce relapses. All tumors limited to the lids must be operated on. If the face or the skull is involved we can no longer speak of lid epitheliomas. They are inoperable and may well be radiated.

Dr. De Vries, Amsterdam, The Netherlands: I had cures in thirty-three of thirty-five cases of tumors of the lid treated with radium and "followed up" to twelve years. Eight growths, more than 20 mm. long, healed with simple, not disfiguring scars. Of twenty cases, only one developed a slight opacity in the posterior lens cortex. Three showed slight erosions shortly after radiation. Severe corneal

lesions are probably due to the use of "soft" rays and the presence of microbes. This can be prevented by using suitable filter, protecting the cornea, and by treatment for a complicating infectious or purulent process in the conjunctiva or tear passages. Protection of the lens requires a (lead) prothesis. Even cases with conjunctival involvement have remained cured for several years.

BIOMICROSCOPY WITH DOUBLE-SLIT DIAPHRAGM. DR. LACARRÈRE, Madrid, Spain.

Anomalies are easily analyzed by the production of a double optical section, and the impression of depth is increased. The second slit can easily be switched off, and examination then proceeds with the ordinary single slit.

GEOGRAPHIC DISTRIBUTION AND INTERNATIONAL CAMPAIGN AGAINST TRACHOMA: SYMPOSIUM

The reports from many different countries considered the number, severity and incidence of trachoma cases, the influence of age, sex, race, social status, constitution, secondary infections, school treatment, living conditions, etc. Preventive, hygienic and therapeutic measures and geographic distribution were also discussed. (In regard to all of these details there appears to be the greatest degree of quantitative and qualitative variation, so that it is impossible to summarize adequately these reports, while on the other hand the publication of statistics and percentages without accompanying details of text explanation and comment are most dry and uninstructive. In general, it may be said that trachoma seems to show a steady decrease in those countries in which both patients and physicians are educated to a better knowledge of the disease conditions and their prevention, causes and treatment. Special medical training, school inspection, general sanitation and promotion of cleanliness, frontier inspection and periodic eye examinations, are all of value. P. H. F.) Secondary infections (gonorrhea, purulent processes) play a very important rôle. The bacterial flora of the normal conjunctival sac and of the trachoma follicles is the same (Lawrynowicz and Melanowski, Warsaw, Poland). The Noguchi bacillus was not found in a single case on bacteriologic examination of ninety-five fresh untreated cases of trachoma. Emulsion of trachoma follicles introduced into the eyes of guinea-pigs failed to produce tubercle bacilli.

DR. PASCHEFF, Sofia, Bulgaria: Conjunctivitis follicularis confluens, true trachoma, shows nodules of chronic lymphadenoid hyperplasia, "folliculomas," of the sclerocornea, tarsus and fornix folds. Epithelial phagocytosis was found, but no special virus. Transplants showed hyaline changes.

DR. ROCHE, Marseilles, France: A study of sporadic cases shows that trachoma does not follow the rules of usual infections. Its communication requires an intermediate host or symbiosis to explain the various degrees of contagiosity. It may be contagious during a certain period only. If this were to be proved, it would greatly simplify the campaign against trachoma, by our simple isolation of the cases during the infectious period.

Dr. Preziosi, Malta: Important measures are compulsory notification, propaganda and early routine treatment beginning in the schools, with improvement of living conditions, an educational campaign and a trachoma council.

Dr. Blatt, Targu-Mures, Roumania: I have noted a general falling off in the number of cases of trachoma and in their virulence. Systematic treatment is the probable cause.

Dr. Brana, Budapest, Hungary: I think that lowered vitality, lymphatic habitus and marshy regions, especially along the coast, with vitamin deficiency are of great importance as etiologic factors. Prophylaxis must be largely hygienic.

Dr. A. Feigenbaum, Jerusalem, Palestine: I have noted the occurrence of yearly epidemics with a regular course, due to infection with Koch-Weeks' bacillus in early summer and to the gonococcus later. This is of the utmost importance in the communication of trachoma which, of itself, is not very contagious. Prophylaxis must be directed principally toward the prevention of these complications.

Dr. J. Landau, Czernowitz, Roumania: I find that many cases of chronic catarrh and follicular conjunctivits are diagnosed as trachoma. This is particularly hard on emigrants who are often refused admittance at a port of entry on account of "suspicious" lids. Persons showing cured trachoma with thin scarring and pale conjunctivae are needlessly deported. International action and examinations of the eyes of immigrants by experienced oculists only are most essential.

Cortical Projection of the Retina. Dr. Noiszewski, Warsaw, Poland.

Descriptive geometry, not optics, explains the formation of three dimensional visual images. The cortical visual field is not merely a mirroring of the retinal on the visual cortex as on a screen. There are a multitude of projections of fields, and the peripheral points of one are fixation points of another, and vice versa. The visual projection of an object in the cortex is a synthesis of visual impression and eye movement. To understand this, we must examine after-images and true visual hallucinations which appear as real objects, and the pseudo-hallucinations which appear as after-images.

DISCUSSION

Dr. I. Abramowitz, Vilna, Russia: I use the ophthalmometer and the image of the mires to determine the strength and axis of cylindric lenses. The method is simple, rapid and accurate enough for practical purposes. In planocylindric lenses the distance from the artificial cornea is to be about 6 mm. With concave cylinders there is overlapping; with convex, separation of the mires.

Biomicroscopy and Sympathetic Ophthalmia. Dr. Jeandelize and Dr. I. Bretagne, Nancy, France.

The slit-lamp enables us to detect at a very early stage the changes characteristic of postoperative (? P. H. F.) or posttraumatic sympa-

thetic iridocyclitis even before the development of clinical symptoms or functional disturbance. None of the other methods of examination will do this.

OPERATIVE TREATMENT FOR KERATITIS EX ACNE ROSACEA. DR. PINES, Bialystok, Poland.

This rather rare but serious disease often results in marked dimunition or complete loss of vision. It may start in the skin of the lids and pass via conjunctiva to the cornea, or appear primarily on the cornea, without involvement of the skin. Dermatologists do not agree on the etiology. It may be akin to acne vulgaris. Others have found special changes in the capillaries. Again, arthritis or kinship with seborrheic eczema is noted. I lay stress on endocrine disturbances and probable racial idiosyncrasy, as all of my patients were at the menopause or of preclimateric age, and almost all Jewesses. Conservative, dietetic and balneologic climatic treatment proved futile. It was decided to perform an operation, similar to Denig's procedure in trachomatous pannus. Relapses were noted in some cases, but the results were in the main encouraging. After-treatment consisted in irradiation with the Birch-Hirschfeld lamp.

TUBERCULOUS SCLEROKERATITIS. DR. ALONSO, Madrid, Spain.

This malady is characterized by a diffuse, not sharply defined, nodular infiltration of the sclera, and later of the cornea with a tendency to vascularization, cheesy degeneration and ulceration, eventually involving the entire uveal tract, particularly the iris. Propagation occurs by hematogenous paths. Treatment must be directed, above all, to improving the general condition. The use of Finsen rays of shorter length (from 350 to 400 microns) with exposures of short duration to be continued steadily for at least three weeks after the disappearance of all signs of disease gives brilliant results.

PTERYGIUM IN MADEIRA. DR. RODRIGUEZ, Funchal, Madeira.

In spite of the statement of Morax and Roure (Encylopédie d'ophthalmologie) that pterygium is endemic in the island, I found in eighteen years of practice that this disease occurs in less than 15 per cent of the cases. The climatologic (brilliant sunlight, wind, dust) and hygienic factors cited by the authors mentioned as favoring the endemic occurrence of pterygium do not exist in Madeira.

SEROUS CYSTS OF THE IRIS. DR. POYALES, Madrid, Spain.

In the iris stroma, these are rarely found, and are generally the result of injury in patients operated on for cataract by "inoculation" of epithelial cells of corneal limbus or lens capsule. Mechanical obstruction (? P. H. F.) explains the marked loss of vision, but tension is not increased as the epithelial cells do not proliferate as far as the ciliary body. Microscopic examination shows two types of cysts: (1) pearl cysts with clearly translucent exudate, and (2) "massive" cysts with an exudate containing lipoids (Fettstoffe). There is a kind of pseudocyst which is found with small hernias or prolapses of the iris

in cataract operations. The content is a transudate from small vessels cut off from the rest of the iris circulation (Ausschwitzung). Serous cysts of the iris may heal spontaneously by rupture of the enclosing membranes or may be dealt with surgically.

DISCUSSION

DR. F. TERRIEN, Paris, France: The serous cysts described by Poyales are always endothelial structures originating in a reduplication or folding of the anterior layer of the iris and they always have an epithelial lining (Auskleidung). The presence of epithelium in traumatic cysts does not in any way invalidate this view of the pathogenesis.

CIRCUMSCRIBED SCLERAL ABSCESS. DR. TERRIEN and DR. FAVORY, Paris, France.

Periscleral purulent abscess with intensely marked chorioretinal reaction was seen in a young girl who had previously been healthy to all appearances. The process resembled a staphylococcus infection of the anterior portion of the sclera, but there was an unusually marked involvement of the adjacent uvea, so that vision was much reduced. The final outcome was most favorable. In a second case the layers under the abscess were not involved and vision was not affected. The staphylococcus infection was here attributed to a general furunculosis. As the conjunctiva was not involved in either case the infection could not have been local. It must have been carried by the periscleral vessels.

DISCUSSION

DR. PASCHEFF, Sofia, Bulgaria: I described a subconjunctival, metastatic staphylococcus abscess due to furunculosis, proved bacteriologically, as far back as 1907.

DR. HILDESHEIMER, Berlin, Germany: Scleral abscess may be favorably influenced by a fresh irritation of the affected eye, e. g., by subconjunctival injections of procaine hydrochloride-epinephrine as in so many other external diseases of the eye. The eye, itself a complete organism in miniature, reacts to acute irritation in disease of long standing, just as the body does.

BILATERAL PREPAPILLARY CYST (HYALOID?). DR. LACARRÈRE, Madrid, Spain.

Flat cystic formations with an uneven, bluish-white, finely striated surface were seen covering the nasal half of the disk and situated on the upper and lower nasal arteries. The cysts seem to be formed of lobules extending below and above, beyond the margin of the disk. No membranous or fibrous formation was seen to extend forward in the direction of the canal of Cloquet. As in other cases of this anomaly reported, there were evidences of chorioretinal pigment degeneration. It is difficult to decide whether this anomaly was congenital or the result of a syphilitic chorioretinitis. It is more probably the result of a degenerative process with cyst formation due, originally, to the retinitis drawing. (A rather poor photograph of the fundus and a more definite drawing of this formation were presented.)

STUDIES WITH TSCHERMAK'S MODIFICATION OF THE HERING HAPLOSCOPE. DR. NOJI, Berlin, Germany.

Studies with Tschermak's useful modification of the Hering haploscope were made to determine whether symmetrical inclination of the corneal meridian, parallel rolling, so far noted only as a reflex with head tilting, could be induced optically. After a monocular after-image of a vertical line had been induced, rotating disks were presented with monocular test objects which were later brought to fusion. After-images proved that rolling (inclination) occurred, probably as a form of corrective motion, as in cyclophoric deviation from the position of rest. With these rollings there is also a revaluation of the retinal meridians in regard to absolute localization.

PALEOBIOLOGIC BASIS OF SO-CALLED FIXATION-PARALYSES. DR. MUSKENS, Amsterdam, the Netherlands.

The peripheral eye and its cerebral projection developed into a definite form early in phylogenesis. The vestibulomotor system took longer. It was markedly altered by the first overlapping of visual fields in the pro-simian, and again when the anthropoid assumed an upright posture and began to carry his spinal column vertically, under the skull, instead of horizontally. The old compensatory movements (symmetric rolling of the corneal axes) were abandoned, and are now noted only as an atavistic remnant, whereas they are the rule in animals with a horizontal trunk and spinal column. Locomotion and associated eye movements develop hand-in-hand with the three semicircular canals and the posterior longitudinal bundle. Eye and body movements take place in three dimensions. Normal body position is a compromise between various inclinations. Nystagmus and conjugate deviation are considered from this point of view.

UNILATERAL AND DISSOCIATED ANTAGONISTIC VERTICAL EYE MOTIONS. DR. BIELSCHOWSKY, Breslau, Germany.

There are two groups: (1) an anomaly which gives a clinical picture suggesting overaction of the inferior oblique concomitant with marked extension of the field of fixation, and (2) dissociated vertical deviation, the anatropia of Stevens.

DISCUSSION

DR. PASCHEFF, Sofia, Bulgaria: Besides unilateral and antagonistic (dissociated) vertical motions of the eyes there is a particular deviation of both eyes, a bilateral form of this deviation. I saw a case in a girl aged 9, with double microphthalmia.

DR. O. ROELOFS, Amsterdam, The Netherlands: Dissociated vertical deviations may be due to faulty alternating, correcting adaptations depending on visual or also on labyrinthine or cerebellar oculomotor stimulation.

EYE MOTIONS AND OTOKINETIC NYSTAGMUS. DR. KESTENBAUM, Vienna, Austria.

Associated eye motions are differentiated into those depending on optic, acoustic or sensory stimuli producing accommodation (Einstellung), and those induced by fixational or labyrinthine stimuli.

DISCUSSION

DRS. CORDS, BIELSCHOWSKY, ROELOFS and OHM took up the question of leading (Führungs) and "command" motions of the eyes, the rôle of vision and fixational factors in the two main phases of nystagmus, motion-perception in the periphery of the retina, and the reflex aiming of the macula in response to an uninterrupted visual stimulus, as opposed to an interrupted stimulus to (labyrinthine?) fixation with a resultant interrupted eye motion (saccade). There may be no qualitative, but merely a quantitative, difference between the quick and the slow component of nystagmus whether optical, cerebral or labyrinthine, as tonus of ocular muscles and the summation of all stimuli—visual, kinesthetic and oculomotor—must be considered. Optic nystagmus may be differentiated from labyrinthine deviation, simply if roughly, by noting the eye motions on passive rotation of the head with, and again without, presenting an object for fixation. The eventual difference between these two values is the optically induced net. Optokinetic nystagmus plays an important part in the localization of brain disease and in the diagnosis of hemianopia, retrobulbar neuritis, squint amblyopia and contractions of the visual field.

EPIDEMIC OF KERATITIS PUNCTATA SUPERFICIALIS. DR. R. E. WRIGHT, Madras, India.

This was a report of 900 cases in Madras from May, 1928, until well into the following year. Slit-lamp microscopy, the etiology (filtrable virus) and the epidemiology were described.

DISCUSSION

DR. S. R. GIFFORD, Chicago: Are the cases of which I see, from fifteen to twenty a year, but never as an epidemic, the same as Wright's? They begin with tearing and photophobia, hyperemia of the lid margin and mild circumcorneal injection. There is no sign of uveitis. Many fine infiltrations, taking fluorescein stain, are seen on the cornea with the slit-lamp, and at times with ordinary focal illumination and the loupe. The corneal nerves are broadened. Slight edema of the epithelium is seen. A few superficial grayish opacities do not stain. The cornea is slightly anesthetic. The tension is perhaps a bit low. Keratitis dendritica never develops.

DR. R. E. WRIGHT, Madras, India: I think that these cases probably belong to the group of keratitis punctata superficialis. There is no reason to expect this form to develop into keratitis dendritica. The latter is typical of herpes febrilis, which is etiologically and clinically distinct from keratitis punctata superficialis. Ethylmorphine hydrochloride combined with atropine and a pressure bandage give the best results.

RETINAL DISEASES

"AZOTEMIC" RETINITIS. DR. TERRIEN AND DR. RENARD, Paris, France.

This was a study of clinical and anatomic relations of nephritis and changes in body fluids to fundus changes, from the diagnostic and prognostic point of view.

HISTOLOGY OF ALBUMINURIC RETINITIS. DR. JAENSCH, Breslau, Germany.

1. There is no direct connection between fatty deposits in the retina in kidney disease and anatomically determinable vascular changes. Angiospasm (Volhard), intra vitam, is a possibility. 2. After long-continued action of the poison and in old subjects, severe atheromatous vessel changes, first of the choroid and later of the retina, occur. 3. There is emulsive (Feintropfig), fatty degeneration of the media and externa of the arteries, with the intima quite or nearly free from fat. 4. Fatty degeneration of the glia, particularly of Mueller's supporting fibers near the basal plates, may precede the appearance of fat deposits in the external retinal layers. As physiologic lipoid intake by glia cells of the retina is unknown, this occurrence is undoubtedly pathologic and must be considered the first step of a nutritional disturbance (Volhard) and as a degenerative process, as described by Krueckmann.

ALBUMINURIC CHOROIDITIS. DR. ADALBERT FUCHS, Vienna, Austria.

Dr. Fuchs discussed the various occurrences of choroidal pigment deposits in nephritis, nephrosclerosis and albuminuric retinitis, presenting as small peripheral depigmentations, large foci of chorioretinitis, the black peripheral deposits with a lighter margin (Elschnig), and Siegrist's "string of pearls" pigment stripe. The pathologic examination of a case showing the last three forms was described. Albuminuric choroiditis, in contradistinction to the retinal involvement in Bright's disease, the histopathologic genesis of which is unknown, is generally due to arteriosclerosis and periarteritis. The choroiditic deposits are prognostically of great importance, as they indicate a decidedly pathologic change in the choroidal vessels and show the serious condition of the patient.

DISCUSSION

DR. PASCHEFF, Sofia, Bulgaria: I saw a case of serous choroiditis during pregnancy in a woman aged 26 who, twenty days before delivery, showed bilateral serous choroiditis with vitreous opacities, followed shortly by detachment. This all disappeared, without treatment, immediately after delivery. All tests, including those of the blood tension, urine, internal organs and endocrine glands, the Wassermann and Pirquet tests, and a roentgen examination, gave negative results except for a small, slightly enlarged bronchial gland. Five years later, vision was 6/10 with correction. Numerous small pigmented and depigmented (white) choroiditic foci in the periphery of the fundus were seen. No eye complications occurred in the course of a second pregnancy. The case is interesting as an example of serous choroiditis with detachment during pregnancy, spontaneous cure, and finally the presence of peripheral choroiditic foci without albuminuria.

RETINITIS IN HYPERGLYCEMIA WITHOUT GLYCOSURIA. DR. CHAILLONS, Paris, France.

In some of these cases there was coincident hypertension. It is of diagnostic as well as therapeutic importance to know that we may find retinitis when there is no sugar in the urine.

RETINAL ARTERIAL TENSION AND INTRACRANIAL PRESSURE. DR. M. BAILLIART, Paris, France.

Generally, a rise in intracranial pressure goes hand in hand with abnormally increased arterial pressure in the retina. Diastolic pressure in the retina is 50 per cent higher than in the brachial artery. Retinal pressure becomes normal when papilledema begins to develop. Hence, local rise in retinal (arterial) blood pressure is to be considered an early symptom of increased intracranial pressure.

RETINAL AND CEREBRAL CIRCULATION. DR. DUBAR and DR. LAUSACHE, Paris, France.

Examination of the fundus has a theoretical and practical value as an indication of the circulation in the brain, showing correspondence with animal experiments. The cervical sympathetic affects both vascular systems similarly. The method sheds light on pressure changes in the cerebrospinal fluid, and on the cause of some obstinate headaches.

RETINAL VASCULAR DISEASE IN EPIDEMIC ENCEPHALITIS. DR. HARTMANN, Paris, France.

A man, aged 23, had severe sleeping sickness. One day before his death, an ophthalmoscopic examination revealed bilateral papillary and juxtapapillary hemorrhages along certain vessels, with slight edema of the retina. There was no papilledema. Histologic examination showed hemorrhages in the nerve fiber layer and pathologic changes in the vessel walls. The nerve was normal.

DISCUSSION

DR. PINES, London, England: Momentary spasms of the retinal vessels occur but are rare. In the sclerotic retina, however, we often see a peculiar form of exudation, which may develop in a few days or even in twenty-four hours. This does not obscure the adjacent vessels, and does not appear as a diffuse opacity (edema), but is sharply defined and delimited from the rest of the retina. This lasts for a few days or weeks. Generally, a vascular ring forms around the exudation with neoformation of very fine vascular twigs on the wall which absorb (ableiten) the exudation, generally with disappearance in from one to two weeks. This process is caused by a vascular spasm of the arterial precapillaries or capillaries. If we had to deal with actual occlusion of vessels, thrombotic or another form, a scar in the retina would inevitably present as a result, while transient spasm does not entirely destroy the retina. Function of a part may be permanently abolished, but circulation is reestablished.

DE LA FOINTAINE VERWEY, Amsterdam, The Netherlands: The existence of vasomotor nerves for the arteries of the brain is not admitted by all physiologists, and they are not affected by epinephrine or stimulation of the cervical sympathetic. Clinically, however, some symptoms can be explained by such a control. Animal experiments support the latter view. Epinephrine, alkalinization of p_H, constricts the vessels. The paradoxic epinephrine reaction is noted only in conditions of acidosis.

After unilateral extirpation of the cervical sympathetic the action of epinephrine on the corresponding side is slight or nil, showing a close relation between epinephrine constriction of the arteries of the pia mater and the cervical sympathetic. Its irritation causes weak contraction of these vessels. Arteries of the brain are hypersensitive in alkalosis.

METHYL ALCOHOL AMAUROSIS. DR. E. MACDONALD, New York.

Three deaths occurred from the ingestion of wood alcohol, preceded by sudden blindness. Pathologic changes were found in the ganglion cells of the retina.

DISCUSSION

DR. H. TYSON, New York: These cases are of importance in America and have been studied by Holden, Schönberg and the speaker, Uhthoff and others. In animal experiments there is a typical toxic retinal edema, with hemorrhages in some severe cases. The chronic type shows nerve fiber changes.

DISEASES OF THE EYE IN VISCOSE OPERATIVES. DR. SANTONOCETO, Forli, Italy.

The workers in artificial silk are subject to a keratoconjunctivitis characterized by the absence of eosinophil cells in the secretion. Just the opposite condition and quite a different clinical picture, namely, marked eosinophilia, were found in one or two cases of burn or corrosion of the conjunctiva and cornea by the fixing fluid used in the viscose process.

DISEASES OF THE EYE IN GLASSBLOWERS. DR. VAN HEUVEN, Utrecht, The Netherlands.

Of 948 eyes, 347 were normal, 249 showed senile cataract, 3 glassblowers' cataract, 3 rupture of the zonule, 53 pigment deposits on the anterior capsule and 89 optic neuritis. Of the last group, 27 showed lowered central color perception, with marked enlargement of the blind spot for white. Vogt claims that glassblowers' cataract is caused by infra-red rays. The iris and the ciliary body, accordingly, which absorb most of these rays are the tissues which are exposed to the greatest danger of damage (? P. H. F.). Tests of accommodation in glassblowers showed a decided lowering of the amplitude of accommodation. In these cases it is not sufficient to examine the lens alone.

DISCUSSION

DR. ELSCHNIG, Prague, Czechoslovakia: The rarity of detachments of the zonular lamellae is striking. Similar lens changes are noted only after roentgen injury. Early loss of accommodation was noted by Lederer (Teplitz). The large number of cases of retrobulbar neuritis reported by van Heuven is striking. Retinal diseases in the absence of other intra-ocular lesions are the commoner occurrence.

DR. VAN HEUVEN: I agree that the cataract is caused by indirect influences. The red and orange optic disks were found in the examinations in the Leerdam (Holland) glass factories. The small percentage

of zonular detachments may be due to my having examined only workers with white glass.

DIAGNOSIS OF DOUBLE PERFORATION OF THE GLOBE. DR. CASTEIGER, Innsbruck, Austria.

This is often in doubt in roentgen examination, especially when a foreign body is located near the posterior wall, on account of the margin of error due to variability in the anteroposterior diameter of the eye. However, the posterior contour of the globe can be made visible by blowing air into (beneath) Tenon's capsule, as shown experimentally (von Staunig, von Herrenschwand), and this at once clears up the question of double perforation, provided always that the x-ray picture is taken promptly, as the injected air is rapidly absorbed and disappears from Tenon's space.

ENTOPTOSCOPY IN POSTERIOR INTRA-OCULAR ANOMALIES. DR. HORNIKER, Trieste, Italy.

Subjective study of the retinal twigs, Scheerer's capillary entoptoscopy, is of value for a knowledge of the physiology and pathology of the macula and optic nerve and the surrounding retina. For this, blue light filtered through Uviol glass must be used. Slight changes in the retina and nerve may require, in addition, ophthalmoscopy with red free light for their detection, although entoptoscopy is the finer method of the two. A particularly successful clinical application of the method is noted in cases of retinitis capillarospastica, in combination with the procedure of Mueller (1855), applied by Hess and Fischer, of observing the capillaries entoptically through a stenopeic opening held close to the eye.

ROYAL SOCIETY OF MEDICINE, SECTION OF OPHTHALMOLOGY

H. DICKINSON, *Reporter*

Feb. 14, 1930

MR. CYRIL H. WALKER, *Chairman*

DISTICHIASIS. MR. J. H. DOGGART.

A girl, aged 7, had had red and watery eyes for a year previous to presentation. There was no history of a similar disorder in any other member of the family. All four lids had a row of accessory cilia arising from the posterior part of the intermarginal surface, finer than the normal lashes. Only a few cases of the condition have been recorded. The histology was first described by Kundt, who demonstrated the absence of meibomian glands, which were replaced by a row of accessory cilia, with sebaceous glands opening into their follicles. Brailey later confirmed these observations. Several instances of more than one case in a family were on record. Some regarded the condition as a reversal to an ancestral malady. Usually there were no symptoms during the

first few years of life. It was proposed to treat the patient in this case by electrolysis, one lid at a time, under general anesthesia; it was preferable to surgical section.

DISCUSSION

DR. COCKAYNE: There seem to be few cases in which the condition is hereditary; I could not find more than five in the records.

MR. LAW: I had a case in a woman who had a double row of lashes in one lid only. I carried out an excision of the accessory row of cilia, by cutting out a V-shaped section and including the lashes as far as I could, following which I employed suturing. It is true that there is a tendency to ectropion of the normal row in cases such as this, but that did not follow in this case. When I saw the patient six weeks later, there seemed to be no tendency to recurrence of the accessory row.

BINOCULAR DETACHMENT OF THE RETINA IN A BOY, AGED 8. MR. A. F. MACCALLAN.

Four years before presentation the boy fell and injured the left supra-orbital region, and since then in order to pick up articles, he has had to go down on his hands and knees to see them. His visual acuity recently was 6/36 with plus 8 sphere in the right eye, and 6/36 with plus 2 cylinder axis vertical in the left eye. In each eye there was a detachment of the retina, and in the upper part there was a yellow band. The general health was good, and the Wassermann reaction was negative. Opinions were asked as to whether anything further could be done for the patient.

MR. A. HUGH THOMPSON: I shall show you a case of double detachment in a boy aged 9 years. He has hypermetropia in each eye of 9 diopters. In the right eye an old detachment overhangs the central part all around. In the left eye the detachment is not nearly so deep.

MR. CYRIL WALKER: A boy, aged 9 years, had a detachment in both eyes, with much haze in the vitreous. Years afterward, while in the Army Service Corps, and in spite of a double detachment, he was able to get 6/60 vision and do useful work.

MR. ARTHUR GRIFFITHS: On the screen is a picture of the eye of a patient whom I exhibited two years ago, with lines of scar tissue similar to those in Mr. MacCallan's case. It was clear that the scar tissue was in the retina.

RETROBULBAR NEURITIS DUE TO NASAL SEPSIS. MISS ROSA FORD.

In October, the retrobulbar neuritis in this case was thought to be due to a latent sinusitis. At a later stage the antrum was opened from the cheek, and a mass of polypoid tissue could be seen on the outer side of the antrum. One of the polypi was removed, and it measured one-half (1.27 cm.) inch in diameter. From it were cultivated *Streptococcus longus, viridans* and *albus*. There seems to be needed a more conclusive diagnostic test for a case of latent sinusitis, because an extra-nasal operation cannot be done in every case of doubtful nature.

PAPILLOMA OF CONJUNCTIVA. MR. ARTHUR GRIFFITHS.

This tumor moved freely over the sclera. It was excised, a quarter of the thickness of the cornea being included. A plastic operation of the conjunctiva was carried out.

PARINAUD'S CONJUNCTIVITIS IN A BOY AGED 17. MR. O. G. MORGAN.

The boy was not brought into contact with horses. A month before presentation the eye in question was irritable, and the preauricular gland began to swell. There was now a sloughing area on the surface which had increased in size. Cultivations from the surface had been done several times, but with negative results, and the gland had come down without suppurating. A diagnosis was to be made with Vincent's angina and syphilis excluded.

DISCUSSION

MR. WILLIAMSON-NOBLE: I have seen a case which looked like one of Parinaud's conjunctivitis, with a large preauricular gland. I excised it with most of the conjunctiva. Material injected into a guinea-pig gave negative results. I dissected out the whole gland, and obtained a tubercle reaction.

COLLOID BODIES IN THE CHOROID. Mr. HUMPHREY NEAME.

The patient, aged 24 years, noted defective vision in the left eye during the few months before presentation. When Mr. Neame examined him three weeks before, he found the vision in the right eye to be 6/9 with only one-quarter diopter astigmatism. The left eye seemed to be emmetropic, and the vision in that was only 6/36 for one letter. He could find no vitreous floating opacities, and therefore he thought that there was no evidence of active inflammation, and so presumed that there were colloid bodies in the choroid. He thought it likely that the low vision in the left eye was congenital.

DISCUSSION

MR. M. HEPBURN: The case does not appear to me to be like one of colloid degeneration of the membrane of Bruch, but rather one of retinal degeneration in the macular region, produced by some disease of the choroidal blood vessels. If that were so, unless a cause for the vascular trouble could be found and successfully treated, the prognosis is bad. The right eye seems to be the seat of the same change as the left, in an early stage.

UNUSUAL COLORATION OF SCLEROTICS. MR. R. FOSTER MOORE.

A woman, aged 54, was admitted to the hospital because of rheumatoid arthritis, for which she had been treated for some years. The Wassermann and Sigma tests were positive. She had alopecia, but it was not supposed to be due to syphilis. The blue coloration of her eyes was unique in Mr. Moore's experience. At first he thought it was a case of blue sclerotics, but she had not had any bones broken, there was no similar condition in members of her family, and it was seen

that the condition did not belong to that group. The slit-lamp showed innumerable particulate dots which could be resolved, and which were not related to the normal pigment of the eye. The patient had taken a number of medicines, but apparently none containing silver. Thirty years before presentation she had a long course of treatment with iron and arsenic.

DISCUSSION

DR. PARKES WEBER: This must be a case of argyrosis.

MR. E. R. HART: This must be a case in which carbolic oil, used for treating an ulcer, resulted in a blue coloration of the cartilage of the ear.

THE RED FIELD AND OPTIC DISK RESISTANCE IN GLAUCOMA AND ALLIED CONDITIONS. MR. RANSOM PICKARD.

Mr. Pickard explained that he had two purposes in view in doing this work: to study the red field in glaucoma, and the factor of resistance of the nerve head to the intra-ocular pressure. He could not, as a result of this four years' work, lay down any definite rules, but the observations were of value.

As far as possible the cases dealt with in the paper were a complete series, not selected. Red $^{10}/_{1000}$ was chosen for comparison with white $^{3}/_{1000}$, because red was more easily identified than green at the margin of the field. The size of the field was estimated by adding the angles subtended by it along the eight principal radii, dividing the total of these by eight, and the result was used as a standard of comparison. The diameter of the blind spot or other scotoma was substracted from the radius or radii in which it appeared. In this paper in 1921 he showed that it was exceptional in normal disks to have a cup area of over 40 per cent. In the present series the numbers were:

	40 per cent or under	Over 40 per cent	Totals
Tension over 27	3	32	35
Tension 27 or less	5	33	38
Intermittent glaucoma	1	6	7
	9	71	80

It would be seen that the series had, as a whole, exceptionally large cups, and yet the cups below 70 per cent might be passed by many as physiologic. The tension was estimated by the Schiötz tonometer, the fingers also being used. In this paper fifty-seven patients were dealt with, most of them being between 55 and 74. In all the groups there was a preponderance of the female sex.

It was shown in the cases of low tension that there was enlargement of the disk cups comparable to that in the cases of definitely raised tension; therefore, the resistance of the nerve head was less in the former than in the glaucomatous group, a point which Mr. Pickard had set out to prove in this paper. In a previous paper he suggested that the cause of this weakness was cavernous atrophy.

Keeping separate the intermittent group, he divided each of the other two groups into two sections: those with an average white radius of 20 degrees or more, and those with less than 20 degrees, the latter comprising the more serious cases.

An examination of normal cases was made to ascertain the variations of the $^{10}/_{1000}$ red field. Of nineteen eyes it was found that six showed a red percentage of less than 60, most of the remainder being above 80 per cent. In other words, one third of them showed small fields. He could not find any cause for this.

In the chart showing the red percentage in cases with an average white radius of over 20 degrees, the close correspondence between the two groups was at once seen, so that either could be substituted for the other without any great inaccuracy. It could be said that about half of each group had a distinctly smaller red field than the normal.

The main anomaly in the red field graphs was that while the two groups with tension over 27 and under 27 had a fairly similar difference from the normal, the intermittent class approximated the normal. It would appear that there was a difference in causation to account for this inconsistency. If it were assumed that in the group with tensions less than 27, an abnormal weakness in the nerve head caused this to give way easily, while in the groups with intermittent glaucoma and a tension of 27 or higher, there was an average resistance power at the spot, then all the groups came into line, each behaving according to the interaction of the resistance of the nerve head and the tension of the globe.

As to the clinical progress of the cases in which the tension was less than 27, eight eyes became definitely worse. Three of these eyes (in two patients) were trephined, but the fields continued to get smaller and the cups to increase. Eight eyes had an increase in the size of the cups, but no decrease in the $^{3}/_{1000}$ field, though three of them had a decrease in the $^{1}/_{1000}$ field.

Eleven eyes were no worse in cups or fields over a period varying from eight months to three and three-quarter years. In these cases the $^{3}/_{1000}$ fields varied from 32 to 9 degrees; the cups, from 100 to 70 per cent. There was one exceptional cup of 12 per cent.

Speaking generally, the larger the cup and the smaller the field, the worse was the prognosis. If it was assumed that the process or processes causing weakness of the nerve head were of varying intensities and durations, so that in some cases the process came to an end before the field was greatly affected, while in others it progressed much further, this explained the varying clinical pictures. If it were also assumed that the nerve fibers and connective tissue elements in the head were variously affected, the severe course of the cases in which trephining was done could be explained by a disease of the nerve fibers, besides that caused by the normal eye tension on nerve fibers insufficiently supported by surrounding connective tissue.

The belief that cases of undemonstrated raised tension and large cups must have raised tension at some unobserved times was founded on variations actually demonstrated at different times in some cases. But this generalization left out the possibility of inherent or acquired weakness of the nerve head, and meant the denial of the variation of one of the two factors which together gave the reason for the enlarge-

ment of the cup when one of them, the ocular tension, was known to vary. It was by sorting out cases which agreed in some signs but differed in others that the varying factors at work could be appreciated. The continued downward trend in some cases of glaucoma for which operation was necessary when no fresh factor such as opacities of the media or inflammation had been introduced suggested a missing influence; the varying resistance of the nerve head supplied this.

In intermittent glaucoma the red field approximated the normal. In the two groups with tension above and below 27, the patients were practically identical in age, sex, size of disk cups and degree of loss of red and white fields, but differed in tension. There was some evidence which suggested that the progress in some of these cases became arrested. If so, it tended to prove that the main factor was the weakness in the nerve head and not the pressure in the globe. There was no evidence as to the nature of the weakness in the nerve head. None of the patients had any symptoms of general disease of the nerves or central nervous system.

H. DICKINSON, *Reporter*

Clinical Meeting, March 14, 1930

MR. CYRIL H. WALKER, *in the Chair*

MELANOSIS GLAUCOMA. MR. J. F. CUNNINGHAM.

A man, aged 56, noticed a spot on the limbus in August, 1929, but refused operation in October. During the six weeks before presentation he had developed definitely increased tension, and a large loss of visual field. The spot, which was chocolate colored, remained, with congested vessels round it. There was a small amount of pigment on the lens capsule. The exhibitor thought it was melanoma which had become malignant.

INJURY TO THE EYE AT BIRTH. SPINY-LIKE FINGERS. LEPROSY OF THE EYE. MR. A. W. ORMOND.

Mr. Ormond showed three cases. The first was one of birth injury to the left eye. Four years prior to presentation the boy was born with a defective left eye, and there were the typical linear scars in the cornea associated with an accident at birth due to the use of instruments. Another boy in the family had also been delivered by forceps, and that boy had a defective right eye but had no corneal changes. He had optic atrophy. The fellow eye was normal, with a vision of 6/6.

The second case was that of a boy who, though he had no lesion of the eye, presented some interesting symptoms. He had what the French termed "spiny-like fingers." The condition establishes itself early in life, often at birth. This boy, now 15 years of age, had a feeble development of the muscles and no subcutaneous fat anywhere in his body.

Mr. Ormond also showed a microscopic specimen from a case of leprosy of the eye.

ANGIOID STREAKS IN THE RETINA. MR. OSWALD MORGAN.

Mr. Morgan presented a case of angioid streaks in the retina, the case having been previously shown in 1927, since which there had been little change. There were also whitish patches, reminding one of retinitis circinata. There were also peripheral patches of choroiditis.

TUBERCULOUS CONJUNCTIVITIS. MR. OSWALD MORGAN.

A case of tuberculous conjunctivitis was again presented, and there was now some granulation tissue, showing typical giant cell formations. The physicians had not been able to find any signs of disease of the chest; there seemed to be no generalized tuberculous condition.

CEREBROMACULAR DISEASE. MR. OSWALD MORGAN.

Mr. Morgan presented a brother and sister with cerebromacular disease. Some years ago they were both noticed to be mentally slow, and both were brought to the hospital because of epileptic fits. The girl showed diffuse pigmentary disturbance at the macula, and the boy had the peripheral type, something like retinitis pigmentosa. Both children went to a school for the blind.

A CASE FOR DIAGNOSIS. MR. OSWALD MORGAN.

The case of a girl was presented for diagnosis. She had always had a defective eye, and for many years had had divergence. The condition of the disk was probably inflammatory. Surrounding the disk were patches of choroidal atrophy and pigmentary disturbance.

BILATERAL COLOBOMA OF THE CHOROID. MR. OSWALD MORGAN.

The patient, a boy, had no vision in the left eye; the right was myopic, and the patient had what Mr. Morgan took to be ciliary vessels coming over the edge of the coloboma. It looked as if the fissure had not closed properly and the vessels had come through the lower level.

DISCUSSION OF MR. MORGAN'S CASES

MR. LESLIE J. PATON: The angioid streaks began with hemorrhage into the outer layers of the choroid, and the result was to produce wrinkling in Bruch's membrane. As to cerebromacular disease, I would not attribute these streaks to typical macular disease.

MR. RAYNER BATTEN: The younger brother had the same condition. The sister's sight failed suddenly in both eyes. She had all the evidences of extensive macular or central hemorrhage. The angioid streaks were in existence long before the hemorrhage occurred. It seemed as if there were chronic leakage from the choroidal vessels, which gave rise to angioid streaks.

MR. R. L. REA: Referring to the condition of tuberculous conjunctivitis, the method practiced by Rollier, in Switzerland, was to invert the eyelids for some minutes at a time and expose the eye to bright sunlight. I have tried that in London, but made the mistake of not having the gland removed, so that though the condition in the eyelid completely cleared up, a gland below the jaw broke down.

LEONTIASIS OSSIA. MR. E. R. CHAMBERS.

A girl, aged 13 years and 6 months, was first seen in 1927. At that time it was thought that there was some enlargement of the face, and that it was a congenital asymmetry; so nothing was done. She came again after two years, and there was then considerable protrusion of the right side of the face, the right orbit was lower than the left and the whole orbit was pushed forward. Vision was less than 6/60. The thyroid was enlarged.

NODULAR KERATITIS. MR. E. R. CHAMBERS.

Another case was one of nodular keratitis. Both corneas showed gray, discrete opacities. The patient's mother, aged 65, had a similar condition, though it was more advanced.

DISCUSSION

MR. A. W. ORMOND: A man, aged 60, who had osteitis deformans, complained of failing eyesight, and at examination retinal hemorrhages were found but no nerve lesion.

KRUKENBERG'S SPINDLES. MR. J. H. DOGGART.

A man, aged 42, had at the back of each cornea a collection of reddish-brown granulations along a vertical line down the middle to the limbus. There were similar granulations circulating in the anterior chamber. But the granulations were not arranged in spindle fashion and there was slight myopia.

TAY'S CHOROIDITIS. MR. ISIDORE SPIRO.

A woman, aged 65, had had failing vision for two years. Vision was 6/36 in the right eye and 3/60 unaided in the left. Both the pupils and the tension were normal. No scotomas were found.

TAR CARCINOMA (?) AND EPIBULBAR CARCINOMA. MR. EASON.

Two cases were presented by Mr. Eason. In one of them the conjunctiva had been injured by tar, though, in the first instance, it was supposed to be a tuberculous lesion. Afterward, however, the sections showed a change resembling carcinoma. The question which arose was whether or not this was tar carcinoma.

The other case of Mr. Eason's was one of epibulbar carcinoma, in which the patient had been treated by radium.

PARINAUD'S CONJUNCTIVITIS. MR. DOYNE for MR. G. G. PENMAN.

The case was shown at the December meeting of the section. Mr. Penman had excised a small portion of the affected conjunctiva and the preauricular gland, which latter was beginning to break down. Guinea-pigs given injections of the material died in six weeks from tuberculosis. The condition of the eye was clearing up well under treatment with a lotion of hydrogen peroxide.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

WILLIAM F. C. STEINBUGLER, M.D., *Secretary*

Feb. 17, 1930

ERNEST F. KRUG, M.D., *Chairman*

XEROSIS OF THE CONJUNCTIVAE. DR. W. BROWN DOHERTY.

In a case of xerosis of the conjunctivae the patient, a girl, aged 19, presented three important considerations: (1) xerotic spots on the conjunctiva of both eyes, (2) nyctalopia and (3) blue sclerotics.

At the age of 6 she developed chronic eczema which lasted for six years. One year later the ocular condition developed. Physical examination gave negative results. Vision was normal in each eye; both sclerae showed a bluish tinge. The cornea, anterior chamber, iris, reaction of the iris, lens, media and fundi were normal. The fields for white and colors and the blind spots were also normal. There was no tension, and no abnormal muscle imbalance. Transillumination showed a marked thinning of the sclera. The conjunctiva of both eyes in the palpebral aperture presented a typical picture of xerotic spots, having the appearance of dried seafoam. The conjunctiva was freely movable and did not produce any exaggerated folds during manipulation. Examination of the secretion showed an abundance of xerosis bacilli.

It has been found that in animals fed on a diet lacking the fat soluble vitamin A there is a marked diminution of the serous secretion of the glands of the conjunctiva and upper respiratory tract. There also exists a deficient regeneration of the visual purple. Xerophthalmia has also been produced by this method. During the World War the disease assumed epidemic proportions because all the butter fat was imported to Germany. Vitamin A is contained in the green parts of plants. When cows eat grass it passes into their milk, being soluble in fatty material. It is present in butter and cod liver oil, but is absent in margarine. A diet deficient in green vegetables, butter and fresh milk is favorable for the development of xerosis. This condition has been known to occur in some cases of profound liver damage.

Dr. Doherty regards this case as possibly one of vitamin deficiency.

DISCUSSION

DR. ARTHUR M. YUDKIN: I have seen a number of cases of this disease; two children were cured by the institution of vitamin which was missing from their diet, but the condition in five adults was not changed following the addition of vitamin A to their diet.

EXFOLIATION OF MOST SUPERFICIAL LAMELLA OF ANTERIOR CAPSULE OF CRYSTALLINE LENS. DR. DANIEL B. KIRBY.

This article appears in full in this issue, p. 93.

DISCUSSION

DR. MARK J. SCHOENBERG: I should like to call attention to a second article by Vogt published in the January number of the *Klinische Monatsblätter für Augenheilkunde.*

DR. ARTHUR M. YUDKIN: Dr. Alling considered this lesion to be a degeneration of the lens capsule. I do not agree.

A CASE OF QUESTIONABLE RETINITIS PIGMENTOSA. DR. EDWARD BELLAMY GRESSER.

The patient, a man, aged 33, a teacher, noticed difficulty in adaptation to darkness in 1915 and disturbance of eccentric vision in 1920. At the time of presentation he complained of progressive loss of vision. At first he had difficulty in adapting himself to light, but now this has been reversed. The patient can see only hand movements. The disks are pink but are not blurred. There is sclerosis of the choroidal vessels, and large patches of sclera are exposed. There are areas of brown pigment and spots of grayish-white exudation. Bone corpuscle pigment is seen in the periphery. Is this a retinitis pigmentosa, a choroideremia, a gyrate atrophy or Troncoso's vasculosa choroidosis?

DISCUSSION

DR. MANUEL URIBE TRONCOSO: The case is interesting from the standpoint of differential diagnosis. It has been suggested that this is a case of retinitis pigmentosa; to my mind there are no good reasons for making such a diagnosis. The case shows a diffuse sclerosis of the choroidal vessels all over the fundus with a small amount of superficial retinal pigment. To this picture the name of "primary atrophy of the choroid" has been applied. This is the classic name for the disease, but in order to suggest the vascular origin of the atrophy, a better designation should be vascular choroidosis. The term, osis, means a degeneration of the choroid. Closely examining the fundus it is easy to see that its striking white color is due to a degeneration of the choroidal vessels in different stages of development, the majority of these vessels being transformed into white cords all over the fundus. In the macular region, and outward and in the periphery, in the right eye, there are two islands of a brownish-red color with choroidal vessels in a good stage of preservation, which accounts for the central and peripheral areas of relative vision which the patient had until two or three months before presentation. Scattered in the periphery and covering the retinal vessels in spots, there are clumps and masses of pigment, some of them of an irregular shape and some with the characteristic features of bone corpuscles. To the latter which are sheathing the retinal vessels the name of perivascular retinal pigment should be applied. In the periphery of the field of vision of the right eye there is a preserved area, corresponding probably to a similar area in the retina in which the choroidal vessels are still present. I wish to call your attention to this interesting point.

This pigmentation of the retina is the so-called "secondary retinitis pigmentosa." That is a bad designation. It suggests that there is some relation between this disease and retinitis pigmentosa on account of the shape of the pigment, when that is not really the case. This bone corpuscle or perivascular pigment and the clumps which cover the vessels are due to the migration of the pigment to the superficial layers of the retina when the retina atrophies as the result of the chorioretinal changes. In this patient the condition is due to a primary degeneration

of the choroidal vessels, and later to a complete atrophy of the whole choroid. At first sight the fundus suggests a congenital absence of the choroid, or choroideremia. This is not the case because the choroid is present, although its vessels are entirely sclerosed. The retina is atrophic, even in the region of the macula, which for many years kept a failing central area of vision. Now this is almost gone, and only a small peripheral island of vision is preserved in the temporal side of the right eye. While retinitis pigmentosa is due to a primary defect of the nervous epithelium of the retina, an abiosis, in this patient the primary changes are in the choroid itself and not in the retina. The choroidosis starts in the vessels and then destroys the whole stroma of the choroid, although, of course, in later stages the retina also atrophies. If this were really a case of retinitis pigmentosa, we should have much more perivascular or bone corpuscle pigment in the periphery of the eye-ground, and its arrangement should be more characteristic. In this patient there are only scattered pigment spots. Another important difference is that in pigmentosa a central area of good vision is preserved for many years, in fact, almost the whole life, while here the central vision is almost gone. The island of peripheral vision preserved in Dr. Gresser's case could not exist in such advanced state of loss of central vision if it were a case of pigmentosa. In regard to the etiology of this vascular choroidosis, Dr. Gresser has not been able to trace it to syphilis or tuberculosis, or to any other general condition. It is probably due to consanguinity or heredity.

DR. ERNEST WALDSTEIN: I believe that the primary trouble lies in the vascular system of the choroid.

UNILATERAL EXOPHTHALMOS WITH SPONTANEOUS PROLAPSE. DR. HUGH S. MCKEOWN.

In this case the exophthalmos was due to a bony thickening in the orbit. Roentgen examination suggests early Paget's disease, but other bony changes must be considered.

DISCUSSION

DR. HARRY A. GOALWIN: I regard this condition as a typical case of circumscribed osteosclerosis of the orbit.

AN UNUSUAL CASE OF CONJUNCTIVITIS. DR. NATHAN BERGER.

The patient, a girl, aged 13, had a persistent conjunctivitis which was due to the introduction of talcum powder into the eyes for the purpose of avoiding having to go to school.

A CASE OF TUMOR OF THE IRIS; BIOPSY. DR. CHARLES LITTWIN.

The patient, a man, aged 57, showed a dark pigmented spherical tumor mass about 2 mm. in diameter, apparently arising from the stroma of the iris at the collaret, between 7 and 8 o'clock. It did not interfere with the pupillary reactions, except when atropine was instilled and the pupil was fully dilated, there was mechanical obstruction to full

dilatation at that point. The rest of the iris was normal in appearance, except just next to this mass there was another minute pigmented spot, but this was not raised from the stroma of the iris. The cornea and other media were clear; the fundus was essentially normal except for tortuous blood vessels and arteriosclerotic changes. Tension of the eyeball was normal. The left eye was normal. A diagnosis of melanosarcoma was made. Slit-lamp examination revealed the tumor to be a cauliflower-like growth attached to the iris by a small pedicle. It was decided to remove this tumor for histologic examination, and this was done on Jan. 21, 1930, by a broad keratome incision and iridectomy.

The pathologist reported this growth as a simple melanoma. There were no sarcoma cells present, although more than a dozen sections were carefully searched.

As regards the differential diagnosis, I quote Wood and Pusey: "In the first stage of its development a small pigmented sarcoma of the iris may easily be confounded with a simple melanoma. The point of greatest importance in the differential diagnosis between these tumors is the fact that a simple melanoma is stationary, while a sarcoma is progressive in growth. If the question should arise as to whether a suspected tumor is increasing in size, and is, therefore, sarcomatous, it would be proper to wait awhile. A month or two would be long enough to settle this point. If the diagnosis cannot be made clinically by waiting, it certainly could be made promptly by examining the suspected growth histologically. It would be proper in a suspicious case to remove a portion of the tumor by iridectomy. Simple melanomas are congenital. This point is of great importance, but one must remember that the patient's evidence in such a matter is frequently very uncertain. . . . It is to be remembered also that simple melanomas do not as a rule project above the plane of the iris. . . . The differential diagnosis from gumma or tubercle in the first stage of development of sarcoma of the iris should offer no difficulty; a tubercle or gumma could not exist long in the iris without causing inflammatory reaction."

ACUTE TUBERCULOUS PERIPHLEBITIS OF THE RETINA AND OPTIC NERVE. DR. ISADORE GOLDSTEIN AND DR. DAVID WEXLER.

This article was published in full in the May issue of the ARCHIVES 3: 552, 1930.

DISCUSSION

DR. BERNARD SAMUELS: The slides illustrating the points presented by Dr. Wexler were excellent. I believe that it is difficult for the process to get into the retina by continuity. It can more easily spread into the choroid. The periphlebitis is probably due to toxins and not to a bacterial infection. Nearly all of these cases of anterior tuberculous periphlebitis sooner or later show a cystic degeneration of the retina, and nearly all develop a detachment of the vitreous.

SOME PRACTICAL PROCEDURES USED BY DR. HAROLD GIFFORD. DR. SANFORD R. GIFFORD.

This article appears in full in this issue, p. 1.

DISCUSSION

DR. ARNOLD KNAPP: Dr. Harold Gifford, as you all know, was one of our great ophthalmologists. He acquired an unusually large clinical experience, and he brought to bear on the study of his cases a mind trained in pathology and bacteriology—an attribute which at that time was unusual. I remember his telling me after returning from abroad that he had planned to stay in New York, to become identified with one of the clinics as pathologist. Unfortunately, he was induced to go to Omaha, and this was a loss for New York. As Dr. Sanford Gifford has said, many of these procedures have appeared in the literature. At the same time many of us have not seen them, and I feel that we owe Dr. Gifford a great debt in having brought so many important facts to our attention. I should like to ask Dr. Gifford whether he would be good enough to tell us what his father's views were in determining the bacteriologic sterility of the conjunctiva before an operation for cataract?

DR. SANFORD R. GIFFORD: In my father's paper on ophthalmic asepsis he found that there was always a normal conjunctival flora. In fifty cultures he took from normal conjunctivae he found bacteria in all but four, and he assumed that they would be found in 100 per cent of the cases if a complete examination of the conjunctival sac was made. In most instances they were saprophytes. He found that it was impossible to sterilize the conjunctival sac by any means that could be used with safety to the cornea. He tried other means by which to sterilize the conjunctiva in a socket after enucleation, and found it was practically impossible to do anything to the conjunctiva which would remove the bacteria as long as from twelve to twenty-four hours, so that in later years he never carried out cultures before operations for cataract. He simply went by the appearance of the conjunctiva, and was against the practice used in some clinics of using a bandage, realizing that it increases the conjunctival flora, and that the normal flora may increase to such an extent as would be dangerous after an operation for cataract. He was careful that no instruments were touched to the conjunctiva before the globe was entered, and tried to avoid implanting bacteria from the conjunctiva into the eye.

Book Reviews

MEDICAL RESEARCH COUNCIL. REPORT OF THE COMMITTEE ON THE PHYSIOLOGY OF VISION: IV. EXPERIMENTS ON BINOCULAR VISION. By N. M. S. LANGLANDS. Price, 2 shillings, 6 pence, net. London: His Majesty's Stationery Office, 1929.

The measure of the visual acuity is the minimum angle between two points where images are just capable of being separated, and it has the value of 1 minute. For a "vernier" consisting of two half lines connected by a line, an angle of 10 seconds between the verticals is sufficient for certain resolution. This is the measure of "vernier acuity."

"Binocular acuity" is the minimum resolvable difference in depth, and is measured by the smallest difference of binocular parallax, which can just be appreciated.

The first recorded measurements were made by von Helmholtz, who obtained an angle eta (η) of 60.5 seconds. An interocular distance of 68 mm. subtends this angle at 230 meters, which he considered his limit of stereoscopic vision. Stratton (1898) found a radius of stereoscopic vision of 580 meters, with an angle of 24 seconds. Later observers found still smaller angles. Howard (1919-1920) examined 106 subjects, and in some found the angle eta (η) as low as from 1.8 to 2.07 seconds.

Some years ago, Langlands made a series of studies, using as a test object the silhouette of a ship, with two masts and a funnel. The masts were 6 cm. apart, 6 cm. high and 3 mm. wide. The observer sat 6 meters away; his head was fixed by making him bite a horizontal, rigid piece of wood. The movable objects, 1.5 cm. in diameter, were placed in front of the masts, or behind them, by an assistant. The angle eta (η) ranged from 1.7 to 9.6 for four observers.

In addition to the tests made with constant illumination, a long series of observations was made, a shutter giving exposures of from 5 to 1,000 milliseconds being used. As the duration of the illumination increased, the binocular acuity improved.

When electric flashes were used, it was determined that even 2 degrees from the center of the fovea the acuity was poor.

Tests made with Pulfricks' stereoscopic test plates gave poor results compared with those made with the unaided eye.

In his recent work, the author was able to obtain a flash of much shorter duration, 1/10,000,000 second. The chief advantage of this is that the eye has no time to move during the flash.

For short flashes a fairly high "instantaneous" binocular or vernier acuity can be reached by practice. One observer attained a binocular threshold of 10 seconds, and a "vernier" threshold a little larger.

The apparatus used to measure vernier acuity consisted of two glass plates, each divided into two parts, one opaque and the other transparent, by a vertical separating line. They were mounted in a disk, with a large rectangular aperture. The upper plate could be moved by a micrometer screw. When the separating line of one plate was a contin-

uation of that of the other, the micrometer read zero. Best (1900) found that when the vernier line was vertical, he could detect a displacement of 13 seconds; when horizontal, the acuity was reduced.

The author described a series of measurements of depth perception when the object consists of three small light disks in a dark field. The perception is shown to be a binocular positional phenomenon varying with the brightness of the disks and their separation.

In explaining binocular acuity, Langlands quoted Fortin's assertion that the cone is too large to function as the ultimate receptor, and that the receptors are a layer of bell-shaped elements between the external fiber layer and the internal nuclear layer. He also outlined his own photo-electric theory. Light falling on the photochemical liquid between the cones causes energy, in the form of emitted electrons, to stimulate the adjacent cones.

The author believes that the binocular perception of depth involves processes more complex than those of the intensity of sensation. Its instantaneous perception probably involves the passage of energy through synapses in higher cortical layers, arising, as it does, from the synthesis and differentiation of two already elaborated unilocular images.

JOHN B. LYNCH.

Directory of Ophthalmologic Societies *

FOREIGN

Oxford Ophthalmological Congress

Master: Dr. A. B. Cridland, Salisbury House, Chapel Ash, Wolverhampton, England.
Secretary: Dr. C. G. Russ-Wood, 12 St. John's Hill, Shrewsbury, England.

NATIONAL

American Medical Association, Section on Ophthalmology

Chairman: Dr. George F. Suker, 25 E. Washington St., Chicago.
Secretary: Dr. William C. Finnoff, Imperial Bldg., Denver.
Place: Philadelphia. Time: 1931.

American Academy of Ophthalmology and Oto-Laryngology

President: Dr. William H. Wilder, 122 S. Michigan Ave., Chicago.
President-Elect: Dr. J. F. Barnhill, Miami Beach, Florida.
Executive Secretary: Dr. William P. Wherry, Medical Arts Bldg., Omaha.
Place: Chicago. Time: October 27-31, 1930.

American Ophthalmological Society

President: Dr. Arnold Knapp, 10 E. 54th St., New York.
Secretary: Dr. Emory Hill, 501 E. Franklin St., Richmond, Va.

SECTIONAL

New England Ophthalmological Society

President: Dr. S. Judd Beach, 704 Congress St., Portland, Maine.
Secretary-Treasurer: Dr. E. B. Dunphy, 520 Commonwealth Ave., Boston.
Place: Massachusetts Eye and Ear Infirmary, 243 Charles St., Boston. Time: 8 p. m., third Tuesday of each month from November to April, inclusive.

Pacific Coast Oto-Ophthalmological Society

President: Dr. Arthur Jones, 105 N. 8th St., Boise, Idaho.
Secretary-Treasurer: Dr. Walter F. Hoffman, 817 Summit Ave., Seattle.
Place: Victoria, B. C. Time: September 3-5, 1930.

Puget Sound Academy of Ophthalmology and Oto-Laryngology

President: Dr. Walter F. Hoffman, 817 Summit Ave., Seattle.
Secretary-Treasurer: Dr. Francis A. Brugman, Medical-Dental Bldg., Seattle.
Time: 8 p. m., third Tuesday of each month, except July and August.

Southern Medical Association, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Fred Hasty, 119 Seventh Ave., Nashville, Tenn.
Secretary: Dr. Fletcher D. Woodward, Box 162, University, Va.
Place: Louisville, Ky. Time: November, 1930.

---

* Secretaries of societies are requested to furnish the information necessary to make this list complete and to keep it up to date.

Southwestern Michigan Triological Society

President: Dr. Wilfrid Haughey, 65 W. Michigan Ave., Battle Creek.
Secretary: Dr. R. H. Fraser, Battle Creek Sanitarium, Battle Creek.
Time: Third Thursday of alternate months.

STATE

Colorado Ophthalmological Society

President: A presiding officer is selected for each meeting alternately until all members have served.
Secretary: Dr. Donald H. O'Rourke, 217 Imperial Bldg., Denver.
Place: First floor, Metropolitan Building, Denver. Time: 7:30 p. m., third Saturday of the month, October to April, inclusive.

Eye, Ear, Nose and Throat Club of Georgia

President: W. L. McDougall, 50 Whitehall St. S. W., Atlanta
Secretary-Treasurer: Dr. William O. Martin, Jr., 384 Peachtree St., Atlanta.

Indiana Academy of Ophthalmology and Oto-Laryngology

President: Dr. H. A. Van Osdol, 320 N. Meridian St., Indianapolis.
Secretary: Dr. Robert J. Masters, 23 E. Ohio St., Indianapolis.
Place: Indianapolis. Time: December 10 and 11, 1930.

Minnesota Academy of Ophthalmology and Oto-Laryngology

President: Dr. C. N. Spratt, 900 Nicollet Ave., Minneapolis.
Secretary-Treasurer: Dr. J. H. Morse, 80 S. 7th St., Minneapolis.

Montana Academy of Oto-Ophthalmology

President: Dr. Lee W. Smith, 125 W. Granite St., Butte.
Secretary: Dr. J. G. Parsons, Lewistown.

North Dakota Academy of Ophthalmology and Oto-Laryngology

President: Dr. H. B. Beeson, 232 W. De Mers Ave., Grand Forks.
Secretary-Treasurer: Dr. F. L. Wicks, Valley City.

Oregon Academy of Ophthalmology and Oto-Laryngology

President: Dr. J. W. McCollom, 346½ Washington St., Portland.
Secretary-Treasurer: Dr. Andrew J. Browning, 418 Mayer Bldg., Portland.
Place: Good Samaritan Hospital. Time: Third Tuesday of each month.

Rhode Island Ophthalmological and Otological Society

President: Dr. J. E. Raia, 276 Broadway, Providence, R. I.
Secretary: Dr. F. W. Dimmitt, 195 Thayer St., Providence, R. I.
Place: Rhode Island Medical Library. Time: 8:30 p. m., second Thursday in October, December, February and April.

Utah Ophthalmological Society

President: Dr. F. M. McHugh, 17 Exchange Pl., Salt Lake City.
Secretary-Treasurer: Dr. H. Leroy Smith, Ezra Thompson Bldg., Salt Lake City.

Virginia Society of Oto-Laryngology and Ophthalmology

President: Dr. Fletcher D. Woodward, Box 162, University.
Secretary-Treasurer: Dr. Henry Grant Preston, Harrisonburg.

LOCAL

Academy of Medicine of Northern New Jersey, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Frederick J. Wort, 1080 Broad St., Newark.
Secretary: Dr. Earl LeRoy Wood, 31 Lincoln Park, Newark.
Place: 91 Lincoln Park South. Time: 8:45 p. m., second Monday of each month.

Academy of Medicine of Toronto, Section of Ophthalmology

Chairman: Dr. Louis Joseph Sebert, 86 Bloor St., W., Toronto.
Secretary: Dr. Alexander E. MacDonald, 151 Bloor St., W., Toronto.
Time: First Monday of winter months.

Atlanta Academy of Ophthalmology and Oto-Laryngology

President: Dr. William L. McDougall, Atlantic National Bank Bldg., Atlanta, Ga.
Secretary: Dr. William O. Martin, Jr., 384 Peachtree St., Atlanta, Ga.
Place: Academy of Medicine, 38 Prescott St. N. E. Time: 8 p. m., last Thursday of each month.

Baltimore Medical Society, Section on Ophthalmology

Chairman: Dr. Leo J. Goldbach, 1012 N. Charles St., Baltimore.
Secretary: Dr. Angus Lloyd MacLean, Johns Hopkins Hospital, Baltimore.
Place: Medical and Chirurgical Faculty, 1211 Cathedral St. Time: 8:30 p. m., fourth Thursday of each month from October to May.

Brooklyn Ophthalmological Society

President: Dr. John N. Evans, 23 Schermerhorn St., Brooklyn.
Secretary: Dr. Michael J. Buonaguro, 589 Lorimer St., Brooklyn.
Place: Kings County Medical Society Bldg., 1313 Bedford Ave. Time: Third Thursday of February, April, May, October and December.

Buffalo Ophthalmologic Club

President: Dr. A. F. Luhr, 40 W. North Ave., Buffalo.
Secretary-Treasurer: Dr. Thurber Le-Win, 112 Linwood Ave., Buffalo.

Chicago Ophthalmological Society

President: Dr. Harry S. Gradle, 58 E. Washington St., Chicago.
Secretary: Dr. Richard C. Gamble, 30 N. Michigan Ave., Chicago.
Place: Medical and Dental Arts Club. Time: Third Monday from October to May.

Cleveland Academy of Medicine, Section of Ophthalmology and Oto-Laryngology

Chairman: Dr. M. Paul Motto, Rose Bldg., Cleveland.
Secretary: Dr. A. D. Ruedemans, Euclid and E. 93d St., Cleveland.
Place: Winton Hotel. Time: Fourth Friday of each month.

Cleveland Ophthalmological Club

Chairman: Dr. W. E. Burner, Guardian Bldg., Cleveland.
Secretary: Dr. M. P. Motto, Rose Bldg., Cleveland.

College of Physicians, Philadelphia, Section on Ophthalmology

Chairman: Dr. Maxwell Langdon, 1530 Locust St., Philadelphia.
Clerk: Dr. Alexander G. Fewell, 1924 Pine St., Philadelphia.
Time: Third Thursday of every month from October to April, inclusive.

Columbus Ophthalmological and Otolaryngological Society

Chairman: Dr. John E. Brown, 370 E. Town St., Columbus, Ohio.
Secretary-Treasurer: Dr. Albert D. Frost, 681 E. Broad St., Columbus, Ohio.
Time: First Monday of each month.

Dallas Academy of Ophthalmology and Oto-Laryngology

President: Dr. D. L. Bettison, Medical Arts Bldg., Dallas, Texas.
Executive Secretary: Dr. W. Mood Knowles, Medical Arts Bldg., Dallas, Texas.
Recording Secretary: Dr. L. A. Nelson, 4105 Live Oak, Dallas, Texas.
Place: Dallas Athletic Club. Time: 6 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Detroit Ophthalmological Club

Chairman: Members rotate alphabetically.
Secretary: Dr. Parker Heath, David Whitney Bldg., Detroit.
Time: 6:30 p. m., first Wednesday of each month.

Eastern New York Eye, Ear, Nose and Throat Association

President: Dr. G. G. Marshall, 122 West St., Rutland, Vt.
Secretary-Treasurer: Dr. Arthur F. Holding, 142 Washington Ave., Albany.
Time: Third Wednesday of October, November, March, April, May and June.

Fort Worth Eye, Ear, Nose and Throat Society

President: Dr. W. R. Thompson, 510 Main St., Fort Worth, Texas.
Secretary-Treasurer: Dr. R. H. Needham, Fort Worth National Bank Bldg., Fort Worth, Texas.
Place: University Club. Time: 6:30 p. m., first Friday of each month except July and August.

Houston Academy of Medicine, Eye, Ear, Nose and Throat Section

President: Dr. Claude C. Cody, 1306 Walker Ave., Houston, Texas.
Secretary: Dr. J. M. Robison, Eye, Ear, Nose and Throat Hospital, Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., first Thursday of each month from September to June.

Indianapolis Ophthalmological and Oto-Laryngological Society

President: Dr. E. L. Lingeman, 241 N. Pennsylvania St., Indianapolis.
Secretary: Dr. Kenneth L. Craft, Hume-Mansur Bldg., Indianapolis.
Place: University Club. Time: 6:30 p. m., second Thursday of each month from October to May.

Kansas City Society of Ophthalmology and Otolaryngology

President: Dr. A. E. Eubank, Argyle Bldg., Kansas City, Mo.
Secretary: Dr. O. S. Gilliland, Professional Bldg., Kansas City, Mo.
Time: Third Thursday of each month from September to May. The November, January and March meetings are devoted to clinical work.

Long Beach Eye, Ear, Nose and Throat Society

President: Dr. Dean E. Godwin, Security Bldg., Long Beach, Calif.
Secretary-Treasurer: Dr. Ferris Arnold, Security Bldg., Long Beach, Calif.
Place: Pacific Coast Club. Time: Last Wednesday of each month from September to June.

Los Angeles County Medical Society, Section on Ophthalmology and Otolaryngology

President: Dr. A. Ray Irvine, 727 W. 7th St., Los Angeles.
Secretary-Treasurer: Dr. J. Frank Friesen, 727 W. 7th St., Los Angeles.
Place: California Lutheran Hospital, Assembly Room. Time: 8 p. m., first Monday of each month.

Medical Society of the District of Columbia, Section of Ophthalmology and Oto-Laryngology

Chairman: Dr. James A. Flynn, 1511 Rhode Island Ave., Washington.
Secretary: Dr. E. R. Gookin, Medical Science Bldg., Washington.
Place: 1718 M St. N. W. Time: 8 p. m., third Friday of each month.

Memphis Society of Ophthalmology and Oto-Laryngology

Chairman: Each member, in alphabetical order.
Secretary: Dr. R. O. Rychener, Exchange Bldg., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month.

Milwaukee Oto-Ophthalmic Society

President: Dr. Edward R. Ryan, 425 E. Water St., Milwaukee.
Secretary-Treasurer: Dr. O. P. Schoofs, 120 E. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., third Tuesday of each month.

Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. R. J. Warner, 706 Church St., Nashville, Tenn.
Secretary-Treasurer: Dr. W. W. Wilkerson, Jr., Bennie-Dillon Bldg., Nashville, Tenn.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month.

New Orleans Ophthalmological and Otological Society

President: Dr. W. A. Wagner, Pere Marquette Bldg., New Orleans.
Secretary-Treasurer: Dr. M. F. Meyer, Canal Bank Bldg., New Orleans.
Place: Eye, Ear, Nose and Throat Hospital. Time: Third Thursday of each month from October to June.

New York Academy of Medicine, Section of Ophthalmology

Chairman: Dr. E. F. Krug, 12 W. 44th St., New York.
Secretary: Dr. William F. C. Steinbugler, 815 Park Ave., New York.
Time: 8:30 p. m., third Monday of every month from October to May, inclusive.

Omaha and Council Bluffs Ophthalmological and Otolaryngological Society

President: Dr. Charles M. Swab, Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. J. C. Davis, 1615 Howard St., Omaha.
Place: Medical Tea Room. Time: 5:15 and 7:00 p. m., third Wednesday of each month from October to May.

Pittsburgh Ophthalmological Society

President: Dr. Edward B. Heckel, Jenkins Arcade Bldg., Pittsburgh.
Secretary: Dr. George H. Shuman, Park Bldg., Pittsburgh.
Place: Pittsburgh Academy of Medicine Bldg. Time: Fourth Monday of each month, except June, July, August and September.

Pittsburgh Slit-Lamp Society

President: Dr. W. W. Blair, 121 University Pl., Pittsburgh.
Secretary: Dr. George H. Shuman, Park Bldg., Pittsburgh.
Place: 121 University Pl. Time: Second Monday evening of every month, except June, July, August and September.

Rochester Eye, Ear, Nose and Throat Society

Chairman: Dr. A. Vincent Walker, 833 South Ave., Rochester, N. Y.
Secretary-Treasurer: Dr. John F. Gipner, 53 Fitzhugh St., Rochester, N. Y.
Place: Rochester Medical Assn., 113 Prince St. Time: 8 p. m., third Monday of each month from October to May.

St. Louis Ophthalmic Society

President: Dr. Charles W. Tooker, 308 N. 6th St., St. Louis.
Secretary: Dr. Carl T. Eber, 1006 Carleton Bldg., St. Louis.
Place: St. Louis or Washington University Cafeteria.
Time: 6:30 p. m., fourth Friday of each month from October to April, inclusive.

San Antonio Ophthalmolo-Oto-Laryngological Society

President: Dr. F. W. Sorrell, Gibbs Bldg., San Antonio, Texas.
Secretary-Treasurer: Dr. A. F. Clark, 728 Main Ave., San Antonio, Texas.
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

Spokane Academy of Ophthalmology and Otolaryngology

President: Dr. A. N. Codd, 421 W. Riverside Ave., Spokane, Wash.
Secretary: Dr. Marc Anthony, Old National Bank Bldg., Spokane, Wash.

Syracuse Eye, Ear, Nose and Throat Society

President: Dr. Searle B. Marlow, State Tower Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. A. Harry Rubenstein, Medical Arts Bldg., Syracuse, N. Y.
Place: University Club. Time: Second Friday of each month except June, July and August.